EVALUATION OF MINING CONSTRAINTS TO THE REVITALIZATION OF PENNSYLVANIA ANTHRACITE

CONTRACT NO. S0241039

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Bureau of Mines Open File Report 47-75

MARCH 1975

BERGER ASSOCIATES **A. B. RIEDEL ASSOCIATES**

NOTICE

BIBLIOGRAPHIC DATA SHEET	1. Report No. BuMines OFR 47-75	2.	
4. Title and Subtitle Evaluation of Mining Constraints to the Revitalization of Pennsylvania Anthracite			5. Report Date March 1975
			6. Performing Organization Code
7. Author(s) Berger Associates and A.B. Riedel Associates			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Berger Associates P.O. Box 1943 Harrisburg, Pa. 17105			10. Project/Task/Work Unit No.
			11. Contract/Grant No. S0241039
12. Sponsoring Agency Name and Address Office of Assistant Director--Mining Bureau of Mines U.S. Department of the Interior Washington, D.C. 20241			13. Type of Report & Period Covered Contract research, 1974-75
			14. Sponsoring Agency Code

15. Supplementary Notes

Approved for release by Director, Bureau of Mines, June 11, 1975.

16. Abstracts The objective of this research was to evaluate the technical and economic constraints on the extraction and utilization of anthracite coal and to determine the research and development needed in order to make anthracite coal more fully utilized as a premium energy resource. In the report the contractor examines in detail the anthracite industry both past and present and evaluates market possibilities. Anthracite reserves and resources are analyzed and tabulated, and the problem of pumping and drainage from the flooded anthracite fields is covered. Current technology is considered in detail with a discussion of production techniques with potential for improvement. The contractor concludes the report with a summary of constraints on the anthracite industry and the contractor's recommendations for effecting a revitalization of that industry. An estimated production of 17 million tons annually by 1990 can be anticipated if adequate planning, research, and development to overcome present constraints are initiated in the near future.

17. Key Words and Document Analysis. 17a. Descriptors

Anthracite mining, Pennsylvania
- Reserves
- Pumping
- Drainage
- Technology
- Production
- Revitalization of industry
- Constraints

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 08I

18. Distribution Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited by NTIS.	UNCLASSIFIED	
	20. Security Class (This Page) UNCLASSIFIED	

FORM NTIS-35(10-70) US COMM-DC 40329-P71

INSTRUCTIONS FOR COMPLETING FORM NTIS-35 (10-70) (Bibliographic Data Sheet based on COSATI Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government, PB-180 600).

1. **Report Number.** Each report shall carry a unique alphanumeric designation. Select one of the following types: (a) alphanumeric designation provided by the sponsoring agency, e.g., FAA-RD-68-09; or, if none has been assigned, (b) alphanumeric designation established by the performing organization e.g., FASEB-NS-87; or, if none has been established, (c) alphanumeric designation derived from contract or grant number, e.g., PH-43-64-932-4.

2. Leave blank.

3. **Recipient's Accession Number.** Reserved for use by each report recipient.

4. **Title and Subtitle.** Title should indicate clearly and briefly the subject coverage of the report, and be displayed prominently. Set subtitle, if used, in smaller type or otherwise subordinate it to main title. When a report is prepared in more than one volume, repeat the primary title, add volume number and include subtitle for the specific volume.

5. **Report Date.** Each report shall carry a date indicating at least month and year. Indicate the basis on which it was selected (e.g., date of issue, date of approval, date of preparation.

6. **Performing Organization Code.** Leave blank.

7. **Author(s).** Give name(s) in conventional order (e.g., John R. Doe, or J.Robert Doe). List author's affiliation if it differs from the performing organization.

8. **Performing Organization Report Number.** Insert if performing organization wishes to assign this number.

9. **Performing Organization Name and Address.** Give name, street, city, state, and zip code. List no more than two levels of an organizational hierarchy. Display the name of the organization exactly as it should appear in Government indexes such as USGRDR-I.

10. **Project/Task/Work Unit Number.** Use the project, task and work unit numbers under which the report was prepared.

11. **Contract/Grant Number.** Insert contract or grant number under which report was prepared.

12. **Sponsoring Agency Name and Address.** Include zip code.

13. **Type of Report and Period Covered.** Indicate interim, final, etc., and, if applicable, dates covered.

14. **Sponsoring Agency Code.** Leave blank.

15. **Supplementary Notes.** Enter information not included elsewhere but useful, such as: Prepared in cooperation with . . . Translation of . . . Presented at conference of . . . To be published in . . . Supersedes . . . Supplements . . .

16. **Abstract.** Include a brief (200 words or less) factual summary of the most significant information contained in the report. If the report contains a significant bibliography or literature survey, mention it here.

17. **Key Words and Document Analysis. (a). Descriptors.** Select from the Thesaurus of Engineering and Scientific Terms the proper authorized terms that identify the major concept of the research and are sufficiently specific and precise to be used as index entries for cataloging.
(b). Identifiers and Open-Ended Terms. Use identifiers for project names, code names, equipment designators, etc. Use open-ended terms written in descriptor form for those subjects for which no descriptor exists.
(c). COSATI Field/Group. Field and Group assignments are to be taken from the 1965 COSATI Subject Category List. Since the majority of documents are multidisciplinary in nature, the primary Field/Group assignment(s) will be the specific discipline, area of human endeavor, or type of physical object. The application(s) will be cross-referenced with secondary Field/Group assignments that will follow the primary posting(s).

18. **Distribution Statement.** Denote releasability to the public or limitation for reasons other than security for example "Release unlimited". Cite any availability to the public, with address and price.

19 & 20. **Security Classification.** Do not submit classified reports to the National Technical Information Service.

21. **Number of Pages.** Insert the total number of pages, including this one and unnumbered pages, but excluding distribution list, if any.

22. **Price.** Insert the price set by the National Technical Information Service or the Government Printing Office, if known.

berger associates
ARCHITECTS ■ ENGINEERS ■ PLANNERS ■ ECONOMISTS

March 26, 1975

Mr. Frank Pavlich, Chief
Section of Contracts
U. S. Bureau of Mines
Western Administrative Office
Branch of Procurement and Property Operation
Building 20
Denver Federal Center
Denver, Colorado 80225

Re: Contract No.S0241039
Evaluation of Mining Constraints to the
Revitalization of Pennsylvania Anthracite

Dear Sir:

It is with pleasure that we submit this report on the prospects for the Revitalization of Pennsylvania Anthracite.

This study was performed pursuant to the terms of an agreement dated June 26, 1974 between the Bureau of Mines and Berger Associates.

The firm of A. B. Riedel Associates acted in the capacity of sub-contractor to Berger Associates, and provided a substantial portion of the input to this report.

Our findings and recommendations - presented in detail in the report - may be summarized in one sentence: A moderate revitalization of the industry, to an estimated production of 17 million tons annually by 1990, can be anticipated if adequate planning, research and development to overcome present constraints are initiated in the near future.

We are most grateful for the support and cooperation received from your organization during the course of our work, and we thank those individuals who gave their time and talent towards the execution of this assignment.

Very truly yours,

F. Heywood Marsh

F. Heywood Marsh
Senior Vice President
Principal in Charge

P.O. BOX 1943 ■ HARRISBURG, PENNSYLVANIA 17105 ■ TELEPHONE (717) 238-9471
OFFICE ■ 101 ERFORD ROAD, CAMP HILL, PENNSYLVANIA

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

7

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

Number | Page

CHAPTER IV (Continued)

CHAPTER V

9

LIST OF PLATES

LIST OF PLATES
(Continued)

LIST OF PLATES
(Continued)

ABBREVIATIONS

AMD - Acid mine drainage

BTU - British Thermal Unit

BUREAU OF MINES (USBM) - United States Department of the Interior, Bureau of Mines.

DER - Commonwealth of Pennsylvania, Department of Environmental Resources.

DOT - United States Department of Transportation

EDCNP - Economic Development Council of Northeastern Pennsylvania

EPA - United States Environmental Protection Agency

ERDA - United States Energy Research and Development Administration

FEA - Federal Energy Administration

IC - Bureau of Mines Information Circular

IMA - Independent Miners and Associates

IMBTA - Independent Miners, Breakers and Truckers Association

MDTA - U. S. Manpower Development Training Act of 1962.

MESA - United States Department of the Interior, Mining Enforcement and Safety Administration

NTIS - U. S. Department of Commerce, National Technical Information Service.

OCR - Formerly U. S. Department of the Interior, Office of Coal Research. Operations transferred to ERDA during recent reorganization.

RI - Bureau of Mines Report of Investigations.

rom - Run-of-mine coal.

SR - Special Research Report of the former Coal Research Board of the Commonwealth of Pennsylvania. Now Department of Commerce of the Commonwealth of Pennsylvania.

UMW - United Mine Workers of America

USGS - United States Department of the Interior, Geological Survey

USRA - United States Railway Association

GLOSSARY OF TERMS

Adit - A horizontal passage driven from the surface for the working or dewatering of a mine.

Backfilling - The filling in of a place from which the coal has been removed.

Bone - A carbonaceous shale containing approximately 40 to 60 percent of noncombustible materials.

Breaker - In anthracite mining, the preparation plant in which the coal is broken, sized and cleaned for market.

Breaker Refuse - The coarse refuse, derived from processing run of mine coal in a breaker; normally rock, slate and bone with small quantities of coal.

Continuous Miner - a mining machine designed to remove coal from the face and to load that coal into cars or conveyors without the use of drills or explosives.

Culm - The waste or slack consisting of fine coal, coal dust and dirt; silt. A vernacular term variously applied, according to the locality.

Drift - A horizontal entry from the outcrop which follows the vein, as distinguished from a crosscut which intersects it.

Gangway - In deep mine development a main haulage road in the coal vein, or, when in rock, generally parallel and adjacent to the coal vein.

Gasification - The partial combustion of carbonaceous fuel so that much of the fuel heat content is retained by the gases formed and is available for later release when burned in other processes.

Grindability - The ease with which coal may be ground fine enough for use as a pulverized fuél. Defined by the Hardgrove Grindability Index.

Measures - A group or series of strata having common characteristics; coal measures.

Mine Refuse - Rock, slate, and bone material, brought to the surface. Mine refuse often contains small quantities of coal, which cannot be economically recovered by processing.

Overburden Ratio - That volume of earth and rock (overburden), measured in cubic yards, overlying a coal measure which must be excavated in order to recover a ton of coal using surface mining methods.

Preparation Plant - Facility where coal is separated from its impurities, washed, sized, and loaded for shipment. In anthracite mining a coal breaker.

Refuse - Waste material in the raw coal.

Reserves - The coal which is considered recoverable by current standards.

Resources - The total amount of coal remaining in the ground.

Shaft - a vertical excavation driven to intersect a coal seam at depth.

Silt - the accumulation of waste, fine coal, bone, and slate settled out of breaker water; culm.

Slant Chute - Chutes driven diagonally within a pitching coal vein as a means to recover coal.

Slope - An inclined passage driven from the dip of a coal vein. An entrance to a mine driven down through an inclined coal seam. The inclination of a mine roadway or coal seam.

Stripping or Surface Mining - the mining of coal by surface mining methods.

Tunnel - Any horizontal entry or drift in a mine, open at one or both ends, which may serve as an adit. Used for haulage, drainage, ventilation or as an egress.

Tunnel Rock - In anthracite mining the sandstone and conglomerate rock produced when tunnels, rock holes and rock gangways are driven to develop coalbeds.

Vein - A mineral body (coal), thin in relation to its other dimensions, and lying within boundaries which clearly separate it from neighboring rock. Variously referred to as a seam or coalbed.

Winning - The excavation, loading and removal of coal from the ground.

PREFACE

A. PURPOSE OF STUDY

On June 26, 1974, the United States Bureau of Mines awarded to Berger Associates Contract No. S0241039, entitled "Evaluation of Mining Constraints to the Revitalization of Pennsylvania Anthracite".

The objective stated in the contract is "To evaluate the technical and economic constraints on the extraction and utilization of anthracite coal and to determine the research and development needed in order to make anthracite coal more fully utilized as a premium energy resource".

The study was to be divided into three phases:

I. Utilization analysis to determine the conditions and extent that anthracite can be used directly or substituted for other fuels.

II. Resource evaluation to catalogue the availability of anthracite.

III. Technological evaluation to determine the applicability of existing technology to anthracite mining and processing and to identify deficiencies in mining technology that inhibit greater utilization of anthracite.

The contract also states: "The product of this study is envisioned as a comprehensive and authoritative report for the use of the energy community and general public in assessing and utilizing anthracite as an energy source, for federal, state, and local officials as a guide and planning document and particularly as a guideline for research and development".

B. CONTENTS OF REPORT

This report essentially examines the existing and potential markets for anthracite coal, determines the quantity, location and depth of the anthracite reserves, and makes recommendations on actions, including research and development, to be implemented in order to revitalize the Pennsylvania anthracite industry.

Following the preface, the report is organized into six chapters.

Chapters I, II and III examine the industry, past and present, and evaluate the market possibilities. (Phase I)

Chapter IV analyzes and tabulates the reserves, or resources, of anthracite remaining in the ground and calculates the cost of pumping. (Phase II)

Chapter V examines the technology of the industry, and recommends where effort should be expended in improving production techniques. (Phase III - part 1)

Chapter VI summarizes the data developed and presents an Action Plan for early implementation and for further research and development projects. (Phase III - part 2) This chapter may be read as an Executive Summary and is printed on colored paper for easy identification.

Each chapter (except VI) is preceded by a summary of its contents, printed on colored paper. Furthermore, in order to make the report as readable as possible, certain voluminous material has been removed to appendices, whose numbers match those of their corresponding chapters. (e.g. P-A-3 means page 3 of the appendix to the preface).

C. ORGANIZATION

This study was performed using the Harrisburg, Pennsylvania office of Berger Associates as a base and A. B. Riedel Associates' Mount Carmel office, in the Western Middle Field, as a support facility.

The following personnel were most closely associated with the study.

F. Heywood Marsh, P.E.	Senior Vice President Berger Associates	Principal in Charge
Alfred B. Riedel, P.E.	President A. B. Riedel Associates	Project Manager and Mining Engineering
Alexander Chamberlin, P.E.	Mining Engineer A. B. Riedel Associates	Technical Design
Norman E. Mutchler, P.E.	Berger Associates	Civil and Environmental Engineering
Richard M. Miller	Director of Economics Berger Associates	Economics
Roy A. Bair, P.E.	Consultant	Mechanical Engineering
Edward M. Lesny, P.E.	Berger Associates	Soils and Geology
Marvin E. White, P.E.	Berger Associates	Civil Engineering
Stephen J. Metague	Berger Associates	Economics
Maisie R. Partridge	Berger Associates	Report Assembly
John R. Schell	Berger Associates	Graphics and Plates

D. METHODS AND PROCEDURES EMPLOYED

D.1 Interviews and Contacts

In a study of this nature, much of the data needed is qualitative. Therefore, an extensive series of interviews was carried out in order to obtain as broad a consensus of the anthracite industry as possible within the budgetary constraints of the contract.

Those interviewed included federal, state and local government personnel, utilities and industrial users, mine operators, preparation plant operators, coal brokers, and union officials.

In addition to actual interviews, much data was obtained by correspondence. If sufficient information was obtained in a letter, an interview was not considered necessary.

There were approximately 115 personal interviews, 25 telephone interviews, and 16 letter responses. A listing of those contacted is contained in the Appendix, beginning on page P-A-1.

Plate P-1 shows the service areas of those electric power companies contacted.

D.2 Research of Published Material

Well over three hundred sources of published material were researched. These varied from government statistics on coal production to the use of coal in steel making to health and safety laws to treatises on the energy crisis.

A list of publications researched is contained in the Appendix, beginning on page P-A-15.

D.3 Field Work

Apart from the interviews mentioned previously, several field trips were made to the anthracite coal fields. These were principally carried out in connection with interviews so as to examine such items as the operation of a coal breaker, the effects of stripping on the landscape, the problems of acidic drainage from mines, and so forth.

D.4 Office Work

From the data collected by research, interviews and inspections, the various projections, text and recommendations were developed.

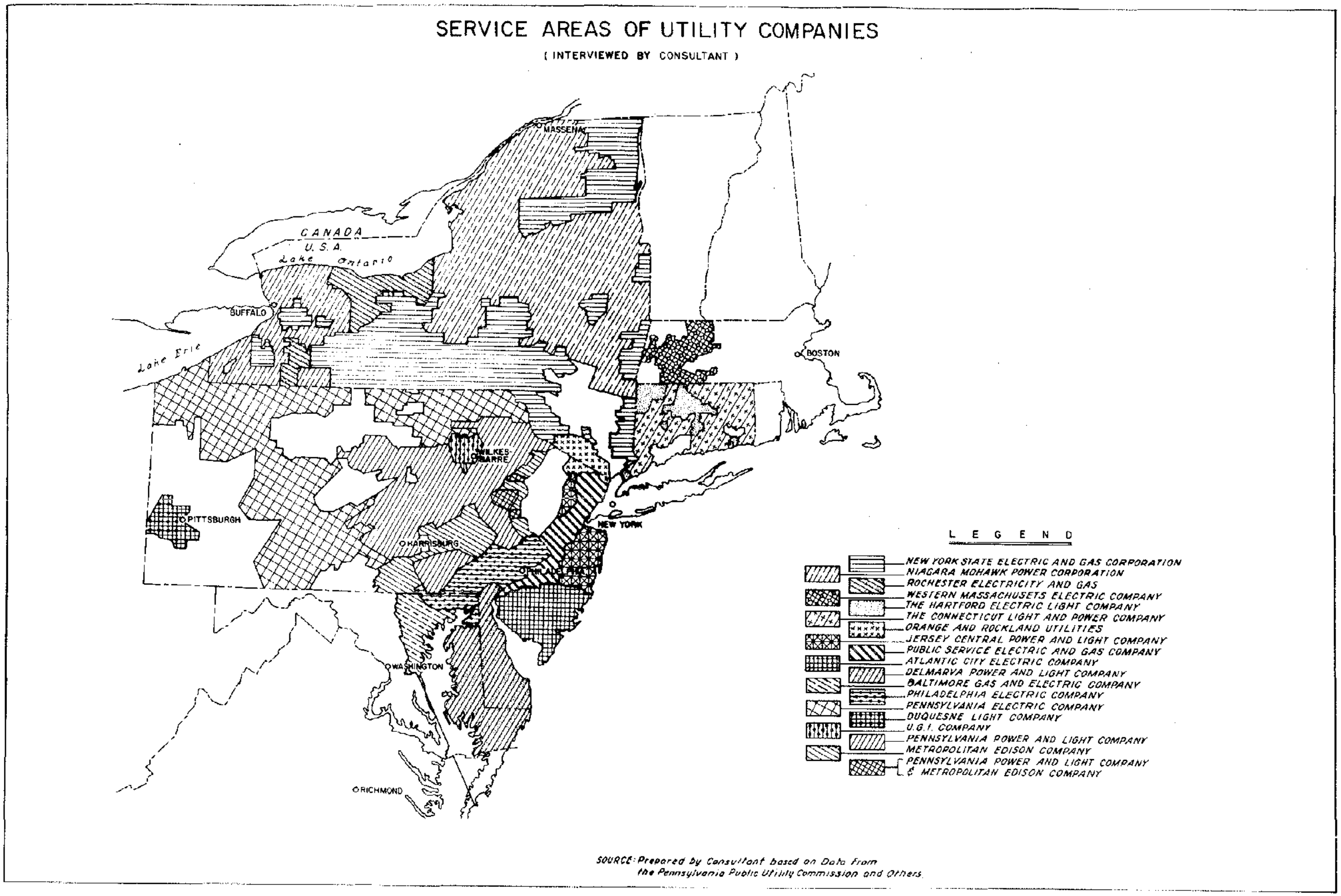

SERVICE AREAS OF UTILITY COMPANIES
(INTERVIEWED BY CONSULTANT)
CANADA
U. S. A.
Lake Ontario
Lake Erie
MASSENA
BUFFALO
BOSTON
WILKES-BARRE
PITTSBURGH
HARRISBURG
NEW YORK
WASHINGTON
RICHMOND
LEGEND
NEW YORK STATE ELECTRIC AND GAS CORPORATION
NIAGARA MOHAWK POWER CORPORATION
ROCHESTER ELECTRICITY AND GAS
WESTERN MASSACHUSETS ELECTRIC COMPANY
THE HARTFORD ELECTRIC LIGHT COMPANY
THE CONNECTICUT LIGHT AND POWER COMPANY
ORANGE AND ROCKLAND UTILITIES
JERSEY CENTRAL POWER AND LIGHT COMPANY
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
ATLANTIC CITY ELECTRIC COMPANY
DELMARVA POWER AND LIGHT COMPANY
BALTIMORE GAS AND ELECTRIC COMPANY
PHILADELPHIA ELECTRIC COMPANY
PENNSYLVANIA ELECTRIC COMPANY
DUQUESNE LIGHT COMPANY
U.G.I. COMPANY
PENNSYLVANIA POWER AND LIGHT COMPANY
METROPOLITAN EDISON COMPANY
PENNSYLVANIA POWER AND LIGHT COMPANY & METROPOLITAN EDISON COMPANY
SOURCE: Prepared by Consultant based on Data From the Pennsylvania Public Utility Commission and Others

PLATE P-1

E. ACKNOWLEDGEMENTS

Numerous government officials, industrial leaders and private persons have kindly given of their time and effort to provide information used in this report. The fact that the names of these individuals do not appear in print in no way lessens the great appreciation of the Consultant for the excellent and willing cooperation of those concerned.

Special gratitude must be expressed to the undernamed, whose guidance and advice contributed considerably to the study.

Ralph H. Whaite	Technical Project Officer	U. S. Bureau of Mines, Wilkes-Barre
Charles S. Kuebler	Chief, Environmental Affairs	U. S. Bureau of Mines, Wilkes-Barre

of heavy earth-moving machines. Dredging from rivers and reprocessing culm banks became more important and these methods now account for about 40 percent of production.

Productivity in 1971, including extraction and preparation, was 6.5 tons per man-day, a composite of: deep mines 4.1 t/md; strip mines 8.4 t/md; culm 31.5 t/md.

The Northern Field was once predominant, now the Southern Field leads with 3.7 million tons in 1970.

From a peak of 180,000 in 1914, employment in the industry dropped to 6,000 in 1970.

Demand is principally for space heating and utilities.

Reasons for decline:

1926 divestment of coal mines from railroad companies resulted in lack of large amounts of capital and in higher freight rates.
Long 1925-26 strike forced many users to other energy sources.
Loss of convenience to oil and gas.
Geologic problems - hard rock overburden
- steep coal pitches
- hardness of coal
Certain aspects of some of the mining and environmental laws are considered inappropriate to anthracite mining.

CHAPTER I - SUMMARY

OVERVIEW OF ANTHRACITE REGION

A. GEOGRAPHIC FEATURES

Anthracite coal is found in ten Pennsylvania counties. There are four anthracite fields - Northern, Eastern Middle, Western Middle, and Southern - totalling 484 square miles. The region is drained by the Susquehanna, Schuylkill and Lehigh Rivers.

B. SOCIO-ECONOMIC FEATURES

Population in the ten counties peaked in 1930 with 1,544,258 residents. The 1970 census showed 1,328,798 persons. There are strong ethnic ties with Eastern and Southern Europe, with Germany, Czechoslovakia and the United Kingdom also being well represented. Negro and Spanish populations are sparse, except in Dauphin County.

The regional labor force of 553,000 is below the national average participation rates. In 1970 the unemployment rate was highest in Lackawanna County, with 5.2 percent. Education attainment is generally below the state median.

All counties, except Dauphin, had median family incomes in 1969 of below the statewide figure of $9,554. Northumberland County was the lowest with $7,354. The textile industry is the major single source of income.

C. HISTORY OF ANTHRACITE MINING

First used in 1769, exports from the region were facilitated by canals (Schuylkill canal, 1825) and, later, the railroads. A peak of nearly 100 million tons was mined in 1917, down to 44 million in 1950, nine million in 1970 and 6.3 million in 1973.

Unionization in anthracite regions was, initially, slow due to strong ethnocentric clusters. The United Mine Workers of America organized in 1897, called major strikes in 1902, 1922 and 1925-26. In 1959, health and welfare payments reached 70 cents per ton compared with 40 cents per ton for bituminous coal.

Most 19th century mining was deep mining, using the room and pillar method. Strip production was introduced in the 20th century with the advent

CHAPTER I

OVERVIEW OF ANTHRACITE REGION

A. GEOGRAPHIC FEATURES

Anthracite coal is found in four distinct fields in the east central and northeastern parts of Pennsylvania. The map on Plate I-1 reveals both the shape and location of the coal basins. Approximately 95 percent of the United States reserves of anthracite (hard) coal is subjacent to this ten county region (Carbon, Columbia, Dauphin, Lackawanna, Lebanon, Luzerne, Northumberland, Schuylkill, Susquehanna, and Wayne).

The fields - Northern, Eastern Middle, Western Middle and Southern - have been separated by geological conditions. They comprise a total of 484 square miles. The northern field is primarily located in Lackawanna and Luzerne Counties. It is a crescent shaped basin and extends for 53 miles from Forest City to Hartville, reaching its widest point of five miles near Wilkes Barre. The area is known as the Wyoming Valley and, contrary to the other fields, it enjoys a cover of rich fertile soil. The Western Middle field occupies a 94 square mile basin of small interconnected valleys surrounded by parallel ridges. Locust Mountain partitions the area into a northern and southern section. The 33 square mile Eastern Middle field more closely resembles a fairly level plateau bordered by Spring and Green Mountains. The City of Hazleton is located in the area. The Southern field is again a basin surrounded by mountain ridges. It covers 181 square miles in Carbon, Schuylkill and Dauphin Counties.

The entire Anthracite Region is drained by three rivers; the Susquehanna, the Lehigh and the Schuylkill. Likewise, the coal producing area is divided into three trade regions - the Wyoming, the Lehigh and the Schuylkill. The coal produced in these areas represents an important mineral fuel resource because of both the magnitude of the reserves and their propinquity to the industrial East Coast.

B. SOCIO-ECONOMIC FEATURES OF THE ANTHRACITE AREA

B.1 Population

The population for the ten county Pennsylvania anthracite area reached its peak in 1930 with 1,544,258 residents reported. The only county to experience appreciable growth in the last half century is Dauphin, whose population has swelled by over 70,000 persons in the period. Lackawanna, Luzerne and Schuylkill counties have experienced the greatest outmigration

ANTHRACITE FIELDS OF NORTHEASTERN PENNSYLVANIA

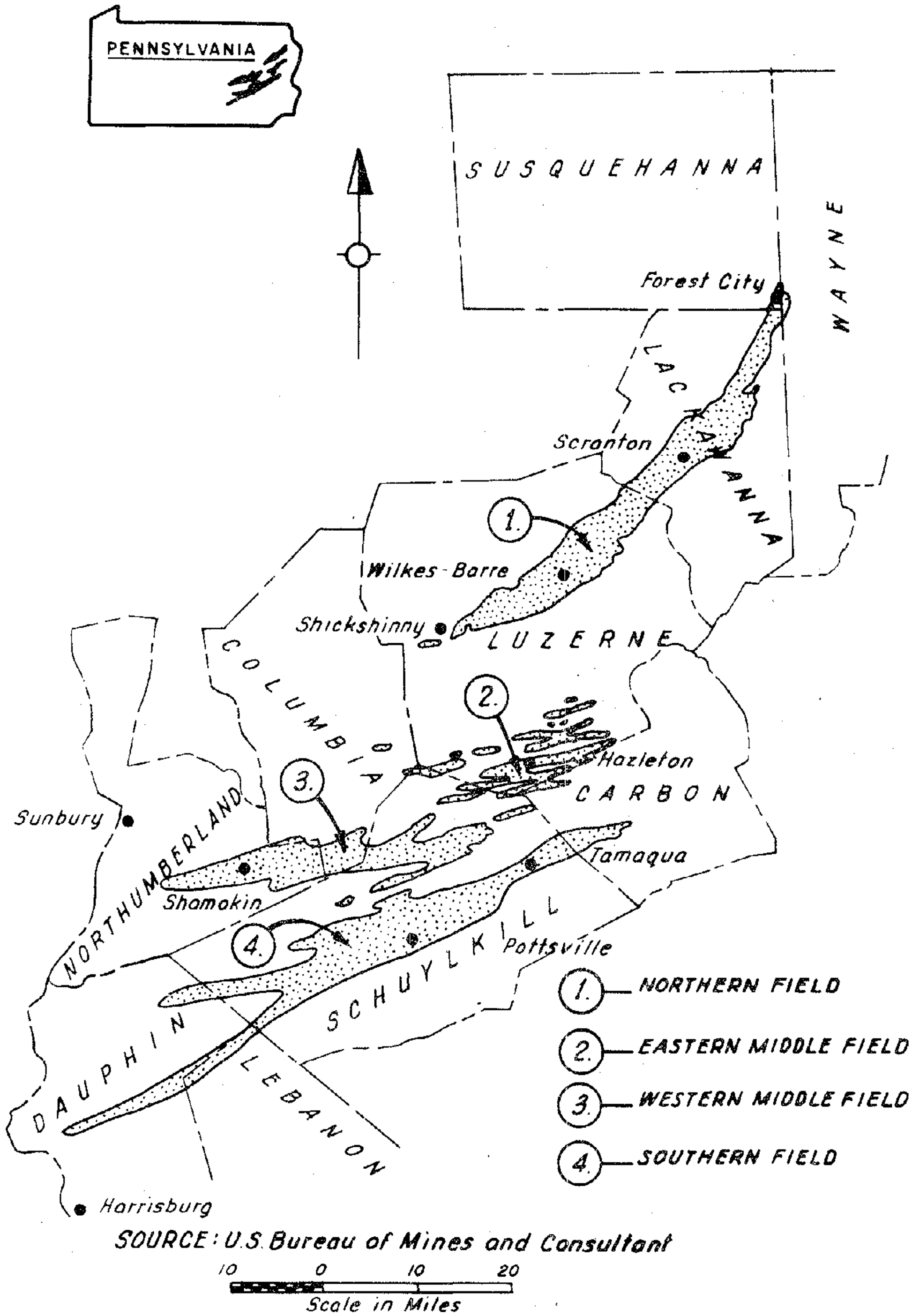


PLATE I - 1

(see Table I-1). The tendency for people to locate where the most job opportunities exist is borne out by the population trend of the coal region. The three counties of intensely declining population had been the major coal counties in the 1920's, employing between 35 and 60 thousand miners each. The number of miners employed today has fallen to a few thousand for the entire region. Conversely, Dauphin County has always had a small mining population but is the leading county of the group for employment in the areas of public administration, construction, transportation and finance.

B.2 Ethnic Backgrounds

The ten county area shows strong ethnic ties to Eastern and Southern Europe. Lackawanna and Luzerne counties evidence an especially heavy incidence of total foreign stock[1] among their populations, 31 and 30 percent respectively. Enclaves of Polish, Austrian and Italian extraction are to be found here. In the entire region Germany, Czechoslovakia, and the United Kingdom are also well represented. Negro and Spanish populations are sparse in all of the counties except Dauphin, where the black population is 11.7 percent of the total population.

B.3 Labor Force

The Anthracite Region of Pennsylvania embraces a total working force of 552,673 persons. The total labor force participation rates of 73.8 percent for males and 42.2 percent for females are both below the national average of 79.2 percent and 42.8 percent respectively. The indication is that a potential for expanding the labor force of the area may exist, especially among males.

The unemployment figures for 1970 range from 1.7 percent in Lebanon County to 5.2 percent in Lackawanna County. The majority of the counties are in the moderate unemployment range when compared to the state average of 4.0 percent in 1970. (See Table I-2).

The unusually high labor force participation rate for Lebanon County (63.3 percent) is coincident with a relatively high income and level economic growth for the area. Wayne County, with its low percentage of working adults (52 percent), has a relatively low county-wide median income and has one of the lowest educational attainment statistics in the area.

---

[1] 'Foreign stock' includes the foreign born population and the native population of foreign or mixed parentage. Persons of foreign stock thus comprise all first - and second - generation Americans.

TABLE I-1

COUNTY POPULATIONS

Ten Counties of the Pennsylvania Anthracite Region
1930, 1950, 1960, 1970

County	1930	1950	1960	1970
Carbon	63,380	57,558	52,889	50,573
Columbia	48,803	53,460	53,489	55,114
Dauphin	165,231	197,784	220,255	223,834
Lackawanna	310,397	257,396	234,531	234,107
Lebanon	67,103	81,683	90,853	99,665
Luzerne	445,109	392,241	346,972	342,301
Northumberland	128,504	117,115	104,138	99,190
Schuylkill	253,505	200,577	173,027	160,089
Susquehanna	33,806	31,970	33,137	34,344
Wayne	28,420	28,478	28,237	29,581
TOTAL	1,544,258	1,418,262	1,337,528	1,328,798

Source: Prepared by Consultant based on data from U. S. Bureau of Census

TABLE I-2

LABOR FORCE SIZE

Ten Counties of the Pennsylvania Anthracite Region
1970

County	Total Labor Force	% of Unemployment	Males 16 and Over	Males 16+ (Working Force)	% of Males in Labor Force	Females 16 and Over	Females 16+ (Working Force)	% of Females in Labor Force
Carbon	20,827	2.6	17,278	12,688	73.4	19,710	8,139	41.3
Columbia	23,290	3.0	19,025	14,085	74.0	21,212	9,205	43.4
Dauphin	97,580	2.2	74,064	57,628	77.8	87,126	39,952	45.9
Lackawanna	97,010	5.2	78,820	58,044	73.6	94,820	38,966	41.1
Lebanon	44,407	1.7	33,502	26,758	79.9	36,656	17,649	48.1
Luzerne	140,892	3.9	116,894	83,220	71.2	138,855	57,672	41.5
Northumberland	40,180	4.0	33,097	24,401	73.7	39,099	15,779	40.4
Schuylkill	64,290	3.8	54,918	39,274	71.5	63,475	25,016	39.4
Susquehanna	13,212	4.2	11,220	8,729	77.8	12,011	4,483	37.3
Wayne	10,985	3.2	10,596	6,999	66.1	10,578	3,986	37.7
Total	552,673	3.4	449,415	331,831	73.8	523,542	220,847	42.2

Source: Prepared by Consultant based on data from U. S. Bureau of Census.

B.4 Education

The level of educational attainment among the adult population of a county is a further indication of the quality of the labor force and the social status of that county. The educational characteristics of the adult population in the Pennsylvania Anthracite Region are disclosed in Table I-3. Among the adult male population two counties, Columbia and Dauphin, display educational attainment levels above the state median level of 11.9 years of schooling. Carbon, Schuylkill and Wayne counties fall far below the state norm. The female adult educational levels among the counties are less divergent and closer to the statewide average in percent of high school graduates and median years of schooling.

B.5 Employment and Personal Income

Of the anthracite counties, only Dauphin had a median family income in 1970 which is above the statewide figures of $9,554. Schuylkill and Wayne Counties are in the relatively low range of median family income. Table I-4 displays further measures of economic development for the counties in the Pennsylvania Anthracite Region. Columns 1-3 are the net shift of population, market value of real estate and value added in manufacture. All three categories compare the actual shift in each county with the shift that would have occurred if the state-wide growth rate had attained. Positive shifts in the market value of real estate and value-added by manufacture in the last decade reveal a short run trend of economic growth. Increases in property values and manufacturing activity augment both the tax base and gross income for the county. Lebanon, Luzerne, Susquehanna, and Wayne Counties showed the greatest appreciation of their economic base in the decade of the 1960's.

The county level of industrial diversification is abstracted in columns (6) and (7) of Table I-4. Generally, the situation where a large percentage of manufacturing employees are in a single industry and where a few industries employ the bulk of the workers, is associated with a county of low economic development. Similarly, a county with an industrial profile which lacks diversification is more vulnerable to the plight of the major industries. Carbon and Wayne Counties evidence heavy reliance on a single industry, in both cases the textile and apparel industry is the economic backbone of the county.

The textile industry is the major single source of income throughout the anthracite region. Only in Dauphin County is income from textile manufacturing preempted by the construction and food products industries. Primary metals, fabricated metals and electrical equipment and sales are the remaining industries predominant in the area. Table I-5 portrays the broad occupational categories of the labor force in the Anthracite Region. Mining was once the major source of income, but as the history of the anthracite industry indicates, a marked decline has occurred in the last five

TABLE I-3

EDUCATIONAL ATTAINMENT LEVELS

Ten Counties in the Pennsylvania Anthracite Region
1970

County	Population 25 and Over	Less Than 8 Years of Education	8-12 Years of Education	1-3 Years College	4 Years or More College	Median Years Completed	% Graduated From High School
MALE							
Carbon	14,314	2,442	10,731	477	664	11.0	43.0
Columbia	14,473	1,266	11,004	749	1,052	12.0	51.0
Dauphin	59,520	7,649	41,522	4,004	6,345	12.1	53.0
Lackawanna	63,686	11,849	41,947	4,751	5,139	11.5	47.0
Lebanon	26,685	3,701	19,837	1,186	1,961	11.6	47.0
Luzerne	95,155	18,515	63,915	5,890	6,835	11.4	46.0
Northumberland	27,384	4,415	20,245	1,167	1,557	11.5	47.0
Schuylkill	45,893	8,252	33,894	1,767	1,980	11.0	43.0
Susquehanna	9,202	1,175	6,936	542	549	11.8	48.0
Wayne	8,751	1,477	6,521	434	519	10.8	42.0
Total	365,063	60,741	256,552	20,967	26,601	11.5	47.0
FEMALE							
Carbon	16,575	2,838	12,243	967	521	11.2	45.0
Columbia	16,486	1,660	12,713	1,264	849	12.1	54.0
Dauphin	70,477	8,430	53,441	4,509	4,097	12.1	53.0
Lackawanna	78,407	14,895	54,825	5,350	3,337	11.8	49.0
Lebanon	29,468	3,961	22,571	1,536	1,406	11.6	47.0
Luzerne	115,315	23,507	81,207	5,944	4,657	11.6	47.0
Northumberland	32,687	5,711	24,579	1,321	1,076	11.2	45.0
Schuylkill	53,588	9,659	40,118	2,320	1,488	11.2	45.0
Susquehanna	9,836	932	7,684	773	447	12.1	56.0
Wayne	8,936	973	6,886	734	343	12.1	52.0
Total	431,775	72,566	316,267	24,718	18,221	11.7	49.0
TOTAL	796,838	133,307	572,819	45,685	44,822	11.6	48.0

Source: Prepared by Consultant based on data from U. S. Bureau of Census.

TABLE I-4

SELECTED ECONOMIC DEVELOPMENT MEASURES

Ten Counties of the Pennsylvania Anthracite Region
1970

County	Population Shift 1960-1970	Real Estate Market Value Shift 60-70	Value Added by Manufacture Net Shift 1960-1970	Median[1] Family Income 1969	Percent of Manufacturing Employment in Largest Industry	Number of Industries to Equal 2/3 of Manufacturing Employment	Population
Carbon	- 4,548	-$ 1,419,000	-$ 8,297,000	$7,949	49.82	1.72	50,573
Columbia	- 641	-$23,076,000	-$19,483,000	$7,958	30.12	3.75	55,114
Dauphin	- 5,726	-$57,530,000	$31,829,000	$9,710	26.15	4.06	223,834
Lackawanna	-10,319	-$19,528,000	$81,899,000	$8,399	32.75	5.61	234,107
Lebanon	4,996	$30,433,000	$ 8,617,000	$9,450	20.14	4.81	99,665
Luzerne	-19,083	$17,674,000	$149,751,000	$8,244	34.16	6.05	342,301
Northumberland	- 9,372	-$12,945,000	$ 6,235,000	$7,354	27.62	4.85	99,190
Schuylkill	-20,244	-$18,524,000	$72,367,000	$7,596	44.76	3.22	160,089
Susquehanna	- 198	$28,524,000	-$ 1,669,000	$8,050	29.32	3.00	34,344
Wayne	169	$101,850,000	$23,097,000	$7,630	55.22	2.20	29,581
Total	-64,966	$45,459,000	$344,347,000	$8,422	35.01	3.93	1,328,798

[1]Pennsylvania Median Family Income for 1969 = $9,554.

Source: Comparative Study of Economic Development in Sixty Seven Counties in Pennsylvania, Pennsylvania Office of State Planning and Development, 1973.

TABLE I-5

OCCUPATION OF LABOR FORCE

Ten Counties of the Pennsylvania Anthracite Region
1970

Occupation	Carbon	Columbia	Dauphin	Lacka-wanna	Lebanon	Luzerne	North-umberland	Schuylkill	Susque-hanna	Wayne
Agriculture, Forestry, and Fishing	191	805	1,292	840	1,359	1,127	805	831	1,183	1,267
Mining	305	90	150	678	977	1,914	718	2,404	170	64
Construction	1,315	1,123	5,950	5,071	2,036	7,823	2,700	4,392	1,121	981
Manufacturing	10,509	10,575	21,191	33,799	18,619	55,150	15,766	28,113	4,363	2,929
Transportation, Communications & Public Utilities	1,401	861	7,345	5,848	2,033	7,333	2,444	3,545	773	520
Retail and Wholesale Trade	2,447	3,501	17,549	18,256	6,783	24,471	6,695	9,106	1,918	1,762
Finance, Insurance, & Real Estate	519	537	4,521	2,797	1,037	4,567	1,008	1,377	389	305
Services	3,044	4,505	23,023	19,698	8,526	26,563	7,105	9,634	2,366	2,263
Public Administration	527	585	14,065	4,759	1,728	6,103	1,248	2,390	360	529
TOTAL	20,258	22,537	95,086	91,746	43,098	135,051	38,489	61,792	12,643	10,620

Source: Prepared by Consultant based on data from U. S. Bureau of Census.

decades. Presently less than two percent of the area payrolls emanate from coal related activities and less than two percent of the area labor force is involved in mining.

C. HISTORY OF ANTHRACITE MINING

C.1 Miners and Mining Methods

The first record of anthracite coal in North America appears on a map by John Jenkins, Sr. in 1762. The "stone coal" was not utilized, however, until the Gore Brothers burned it in a Wilkes-Barre blacksmith shop in 1769. Anthracite soon became popular among blacksmiths in the area as a source of clean, steady heat. The first domestic use of anthracite also occurred in Wilkes-Barre. Judge Jesse Fell fired the coal in a home designed furnace in 1808.

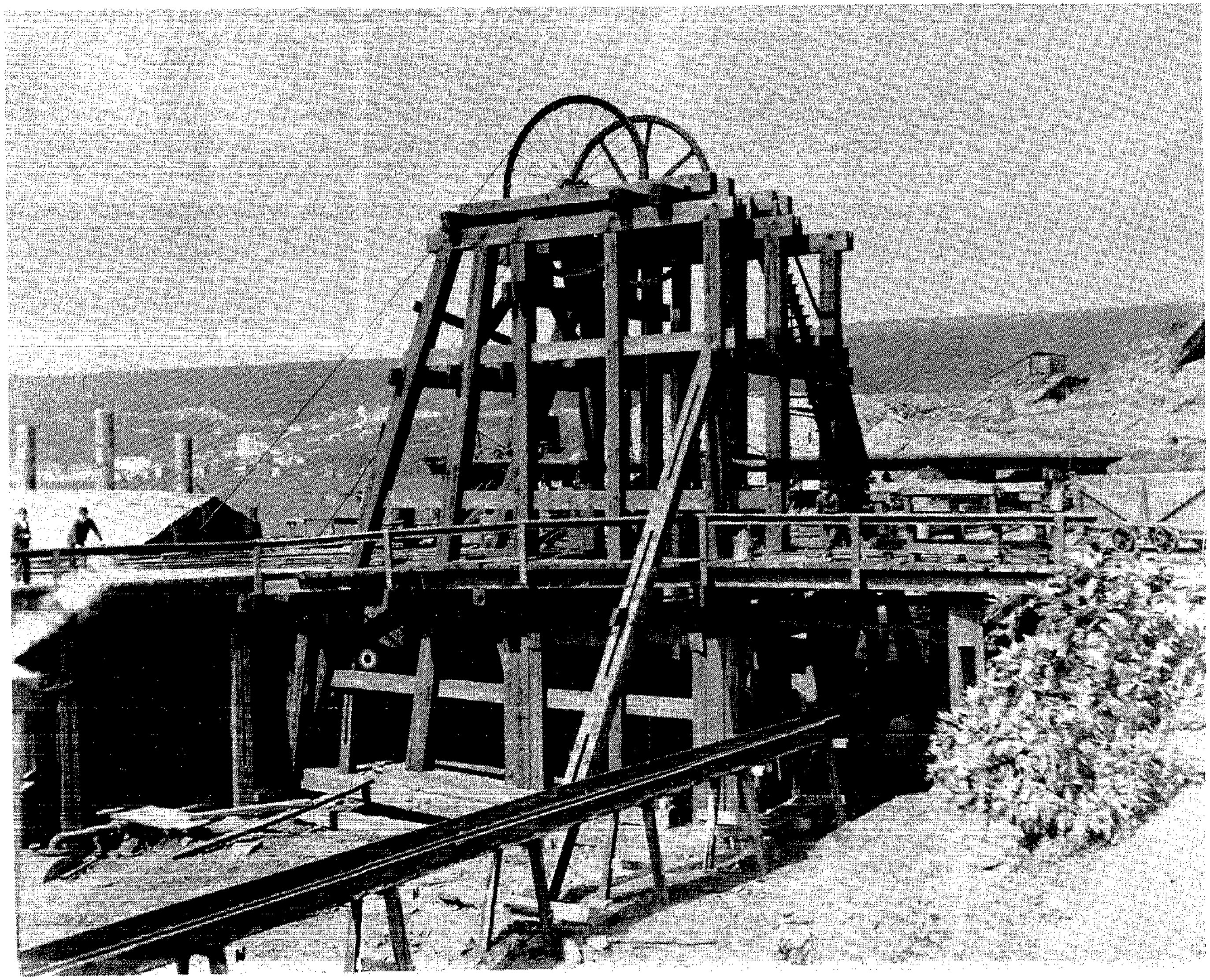
The anthracite industry grew slowly at first but steadily throughout the 19th century. The difficulty in igniting anthracite and the relative abundance of firewood hindered its early use as a fuel. By 1820, however, 2,500 tons of the coal are reported to have been shipped from the Wyoming Valley.

Overland shipping of coal was prohibitively expensive. River routes could be used to transport the coal when the water was high. The Schuylkill Canal, completed in 1825, allowed the first reliable route of entry to the Philadelphia coal market. By 1846 the anthracite canal system totaled 643 miles and transportation costs declined over time. By 1870 the growth of railroads precipitated the decline of canal haulage of coal by assuming a greater share of the task.

As transportation systems improved and further uses of anthracite developed, mine workers penetrated the earth in increasing numbers. No accurate record of employees exist before 1870, but by that time the industry employed some 36,000 workers.

In the early years of the industry, when the demand for anthracite was small, sufficient quantities could be gathered by digging and wedging the coal loose along outcroppings. As demand grew, deep mining became the common form of coal extraction.

In the 19th century most coal was deep mined. Miners retrieved the earth's coal through four distinct types of openings; drift, slope, tunnel and shaft. The "drift" mine developed as workers dug coal from an outcropping which occurred at the base of an incline. The workers followed the seam upward as they dug into the hill. The "slope" similarly followed a seam of coal from an outcropping but along a declining plane. The "tunnel" method provided access to coal seams that were above the water table. The "shaft" reached coal seams buried 200 or more feet below the surface.



HEAD ERAME
WILLIAM PENN COLLIERY
September, 1894

From the Collection of the Smithsonian Institution

AN EARLY MECHANICAL LOADER
ALASKA COLLIERY - 1915
PHILADELPHIA & READING COAL & IRON COMPANY

From the Collection of the Smithsonian Institution

The shaft method employed a vertical entrance to the coal seams where gangways were driven to enter and develop the vein. Here the miners extracted coal along the seam. Furnaces at the bottom of the shaft rarified the air to assure circulation. Towards the end of the 19th century, fans replaced the furnaces in providing ventilation.

At the surface of the deep mine stood the breaker. The task of this facility was to clean and process the freshly mined coal for market. Anthracite burns most efficiently when it is fairly uniform in size and contains few impurities. The coal was, and still is, marketed by sizes; egg, stove, chestnut, pea, buckwheat, rice and barley. At first the run-of-the-mine coal was broken and cleaned by hand. In 1844 the first mechanical breaker was adopted. Gravity fed coal was crushed by small power-driven, toothed, cast iron rolls and separated into sizes by a series of screens. Slate pickers still cleaned the coal by hand. In the 1870's the slate pickers were gradually replaced by jigs which cleaned and separated the coal by specific gravity.

Although technology replaced workers at the surface of the mine, the underground work remained - and remains - immune to sweeping changes. Geologic conditions have limited mechanization to loading and haulage. Improvements have also occurred in dewatering and ventilating. The extraction cycle at the mine face, however, is still primarily the work of men aided by mechanical drills and blasting.

C.2 Labor Relations and Working Conditions

By modern standards, working conditions in the 19th Century anthracite industry were deplorable. The safety of workers was jeopardized by poor lighting and ventilation, cave-ins, mine water, blasting and coal gas. A mine worker generally began his career between the ages of four and ten as a slate picker. He then progressed up the mine worker's hierarchy to an errand boy and eventually entered the mine as a door boy. Age and experience allowed the worker to progress to a mule driver, laborer and eventually a miner. Pay and status among mine workers was decided by skill and the importance of a job in the operation of the mine.

Immigrants provided an important source of labor for the anthracite industry. Upon arrival into the coal region immigrants lived, and worshipped, in ethnocentric clusters. Ethnocentrism hindered the early movement to organize labor. The first united action by mine workers occurred in 1842 but was disbanded by the militia before the workers could gain any of their objectives. The period from 1865 to 1887 was characterized by attempts at collective movements, work stoppages, and violence. In 1897 the United Mine Workers of America began to organize throughout the region. Several strikes have occurred since the U.M.W. gained power. In 1902 a contract dispute led to a strike which lasted 165 days. Major strikes plagued the industry again in 1922 and 1925-26, each stoppage lasted between five and six months. The decline of the anthracite industry is sometimes partially attributed to these strikes, which encouraged consumers to seek a more dependable source of fuel.

The U.M.W. fought to protect existing miners as their ranks began to thin in the 1930's, and the "equalization of work time" clause became a part of the anthracite contract. The result was that companies with numerous mines found themselves working only two to four days a week at prohibitive costs.

The Union health and welfare fund also developed. By 1959, health and welfare payments demanded by anthracite workers reached 70 cents per ton of coal mined. The competitive position of anthracite coal was hurt vis-a-vis bituminous coal where benefits remained at 40 cents per ton.

In the last 40 years membership in the United Mine Workers has declined in the region. As an outgrowth of the Depression the Independent Miners and Associates and the Independent Miners, Breakers and Truckers Association have grown in relative importance.

C.3 Production

The production of anthracite expanded noticeably following the Civil War as coal was used to power the industrialization of the United States. By 1917 the industry reached its peak year and produced nearly 100 million tons of the hard coal. The rise in output from 1890 is traced in Plate I-2 and Table I-6. The only serious decline to hit the industry before 1917 occurred during the strike of 1902, when over 25 million tons were lost to the nation. Strikes again crippled output in 1922 and 1925. As alternative fuel sources became abundant the industry never fully recovered from the last major strike. The Depression curtailed demand and supply further. Since then the downward trend in output was only briefly reversed by World War II.

In the 19th century almost all production had been of the deep mine variety. The first quarter of the 20th century heralded the inception of strip and dredge mining. Strip mining required large scale excavation and was not practical until adequate equipment became available.[1] Table I-6 shows the gradual growth of strip mining until the middle of the 20th Century. At first, only a small portion of total production was strip mined, but by 1970 almost half of the output was culled from the land in this

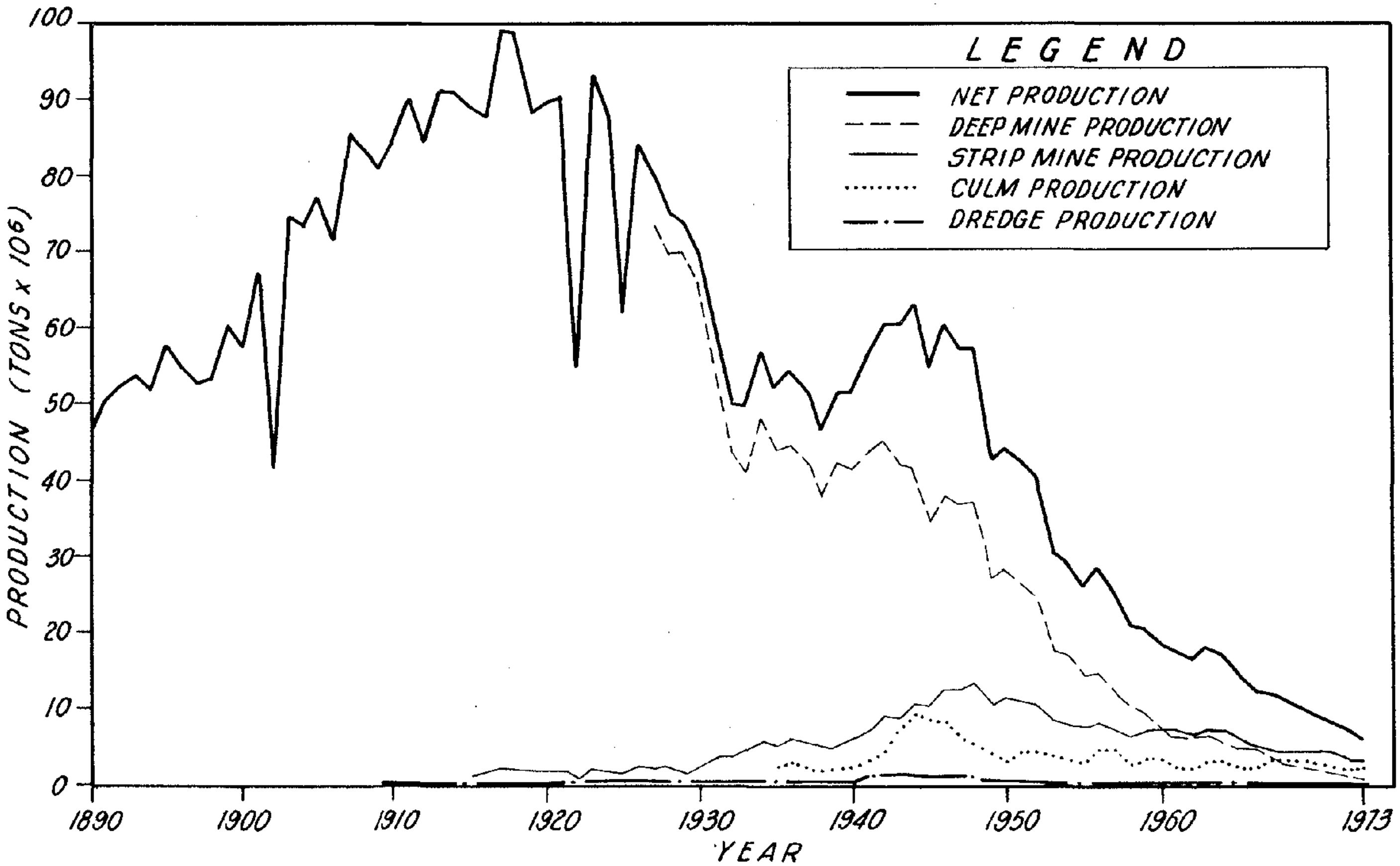
---

[1]The quarrying of anthracite along the exposed outcrops was the forerunner of strip mining. One of the earliest attempts occurred at Summit Hill in 1821. Exposures were hand excavated with shovel and wheelbarrow.

PRODUCTION TRENDS FOR PENNSYLVANIA ANTHRACITE

PENNSYLVANIA ANTHRACITE REGION

1890 – 1973



SOURCE: Prepared by Consultant based on Data from the U.S. Dept. of Interior, Bureau of Mines, Minerals Yearbook, Selected Years

PLATE I - 2

TABLE I-6

PRODUCTION TRENDS

Pennsylvania Anthracite
1890-1973

Year	Net Production (Tons)	Methods of Production				Productivity: Tons Per Man Day		Quantity Loaded Mechanically Underground	Percent Of Total Loaded Underground
		Deep Mine	Strip	Culm	Dredge	Total Average	Strip Average		
1890	46,468,641	N/A	N/A	N/A	N/A	1.85	N/A	N/A	N/A
1891	50,665,431	N/A	N/A	N/A	N/A	1.98	N/A	N/A	N/A
1892	52,472,504	N/A	N/A	N/A	N/A	2.06	N/A	N/A	N/A
1893	53,967,543	N/A	N/A	N/A	N/A	2.06	N/A	N/A	N/A
1894	51,921,121	N/A	N/A	N/A	N/A	2.08	N/A	N/A	N/A
1895	57,999,337	N/A	N/A	N/A	N/A	2.07	N/A	N/A	N/A
1896	54,346,081	N/A	N/A	N/A	N/A	2.10	N/A	N/A	N/A
1897	52,611,681	N/A	N/A	N/A	N/A	2.34	N/A	N/A	N/A
1898	53,382,645	N/A	N/A	N/A	N/A	2.41	N/A	N/A	N/A
1899	60,418,005	N/A	N/A	N/A	N/A	2.50	N/A	N/A	N/A
1900	57,367,915	N/A	N/A	N/A	N/A	2.40	N/A	N/A	N/A
1901	67,471,667	N/A	N/A	N/A	N/A	2.37	N/A	N/A	N/A
1902	41,373,595	N/A	N/A	N/A	N/A	2.40	N/A	N/A	N/A
1903	74,607,068	N/A	N/A	N/A	N/A	2.41	N/A	N/A	N/A
1904	73,156,709	N/A	N/A	N/A	N/A	2.35	N/A	N/A	N/A
1905	77,659,850	N/A	N/A	N/A	N/A	2.18	N/A	N/A	N/A
1906	71,282,411	N/A	N/A	N/A	N/A	2.25	N/A	N/A	N/A
1907	85,604,312	N/A	N/A	N/A	N/A	2.35	N/A	N/A	N/A
1908	83,268,754	N/A	N/A	N/A	N/A	2.39	N/A	N/A	N/A
1909	81,070,359	N/A	N/A	N/A	107,788	2.31	N/A	N/A	N/A
1910	84,485,236	N/A	N/A	N/A	102,853	2.17	N/A	N/A	N/A
1911	90,464,067	N/A	N/A	N/A	106,005	2.13	N/A	N/A	N/A
1912	84,361,598	N/A	N/A	N/A	96,009	2.10	N/A	N/A	N/A
1913	91,524,922	N/A	N/A	N/A	150,064	2.02	N/A	N/A	N/A
1914	90,821,507	N/A	N/A	N/A	115,257	2.06	N/A	N/A	N/A
1915	88,995,061	N/A	1,121,603	N/A	138,421	2.19	N/A	N/A	N/A
1916	87,578,493	N/A	1,987,800	N/A	160,507	2.16	N/A	N/A	N/A
1917	99,611,811	N/A	2,301,588	N/A	170,672	2.27	N/A	N/A	N/A
1918	98,826,084	N/A	2,360,183	N/A	282,930	2.29	N/A	N/A	N/A
1919	88,092,201	N/A	2,006,879	N/A	693,093	2.14	N/A	N/A	N/A
1920	89,598,249	N/A	2,054,441	N/A	740,453	2.28	N/A	N/A	N/A
1921	90,473,451	N/A	2,027,790	N/A	623,329	2.09	N/A	N/A	N/A
1922	54,683,022	N/A	949,745	N/A	904,108	2.31	N/A	N/A	N/A
1923	93,339,009	N/A	2,263,098	N/A	956,368	2.21	N/A	N/A	N/A
1924	87,926,862	N/A	1,865,677	N/A	825,394	2.00	N/A	N/A	N/A
1925	61,817,149	N/A	1,578,478	N/A	1,015,708	2.12	N/A	N/A	N/A
1926	84,437,452	N/A	2,401,356	N/A	914,764	2.09	N/A	N/A	N/A
1927	80,095,564	73,657,818	2,153,156	N/A	971,817	2.15	N/A	2,223,281	3.0
1928	75,348,069	69,724,862	2,422,924	N/A	943,401	2.17	N/A	2,351,074	3.4
1929	73,828,195	69,963,848	1,911,766	N/A	716,944	2.16	N/A	3,470,158	5.0
1930	69,384,837	64,926,094	2,536,288	N/A	643,291	2.21	N/A	4,467,750	6.9
1931	59,645,652	53,459,502	3,813,237	N/A	458,750	2.37	N/A	4,384,780	8.2

TABLE I-6 (CONTINUED)

PRODUCTION TRENDS

Year	Net Production (Tons)	Methods of Production: Deep Mine	Methods of Production: Strip	Methods of Production: Culm	Methods of Production: Dredge	Productivity: Tons Per Man Day: Total Average	Productivity: Tons Per Man Day: Strip Average	Quantity Loaded Mechanically Underground	Percent Of Total Loaded Underground
1932	49,855,221	43,834,160	3,980,973	N/A	480,050	2.54	N/A	5,433,340	12.4
1933	49,541,344	41,032,111	4,932,069	N/A	538,924	2.60	N/A	6,557,267	16.0
1934	57,168,291	48,574,741	5,798,138	N/A	652,180	2.53	N/A	9,284,486	19.1
1935	52,158,783	43,782,876	5,187,072	2,702,468	590,467	2.68	N/A	9,279,057	21.2
1936	54,579,535	44,726,506	6,203,267	3,193,972	546,684	2.79	N/A	10,827,946	24.2
1937	51,856,433	42,566,351	5,696,018	2,722,599	760,474	2.77	N/A	10,683,837	25.1
1938	46,099,027	38,142,297	5,095,341	2,340,444	571,024	2.79	N/A	10,151,669	26.6
1939	51,487,377	42,571,548	5,486,479	2,583,814	703,860	3.02	N/A	11,773,833	27.7
1940	51,484,640	41,516,837	6,352,700	2,783,038	942,944	3.02	N/A	12,326,000	29.7
1941	56,358,267	43,877,264	7,316,574	3,656,866	1,517,563	3.04	N/A	13,441,987	30.6
1942	60,327,729	45,236,699	9,070,933	4,735,064	1,285,033	2.95	N/A	14,741,459	32.6
1943	60,643,620	42,735,798	8,989,387	7,583,698	1,334,737	2.78	N/A	14,745,793	34.5
1944	63,701,363	41,755,416	10,963,030	9,600,180	1,372,737	2.79	N/A	14,975,146	35.8
1945	54,933,909	34,885,699	10,056,325	8,786,659	1,205,226	2.79	N/A	13,927,955	39.9
1946	60,506,873	38,084,457	12,858,903	8,431,092	1,132,394	2.84	N/A	15,619,162	41.0
1947	57,190,009	36,963,112	12,603,545	6,403,646	1,219,706	2.73	N/A	16,054,011	43.4
1948	57,139,948	37,175,291	13,352,874	5,623,779	988,004	2.81	N/A	15,742,368	42.3
1949	42,701,724	27,030,650	10,376,808	4,429,144	865,122	2.87	N/A	11,858,088	43.9
1950	44,076,703	28,155,895	11,833,934	3,467,310	619,564	2.83	N/A	12,335,650	43.8
1951	42,669,997	26,342,239	11,135,990	4,630,200	561,568	2.97	N/A	10,847,787	41.2
1952	40,582,558	24,748,283	10,696,705	4,765,516	372,054	3.06	N/A	10,034,464	40.5
1953	30,949,152	17,893,489	8,606,482	4,011,000	438,181	3.28	N/A	6,838,769	38.2
1954	29,083,477	16,852,408	7,939,680	3,565,482	725,907	4.02	N/A	6,978,035	41.4
1955	26,204,554	14,498,758	7,703,907	3,213,046	788,843	3.96	N/A	6,660,939	45.9
1956	28,900,220	15,054,904	8,354,230	4,774,739	716,287	4.25	N/A	7,308,110	48.5
1957	25,338,321	12,616,053	7,543,157	4,521,410	657,701	4.18	N/A	6,657,479	52.8
1958	21,171,142	10,698,835	6,877,761	2,902,753	691,793	4.36	7.94	5,332,043	49.8
1959	20,649,286	9,415,470	7,096,343	3,420,854	716,619	5.12	9.40	4,700,542	49.9
1960	18,817,441	7,695,978	7,112,288	3,297,012	712,163	5.60	10.51	4,044,392	52.6
1961	17,446,439	6,784,586	7,246,646	2,669,359	745,848	5.63	10.96	3,337,778	49.8
1962	16,893,646	6,672,922	6,822,207	2,671,466	727,051	5.92	11.01	3,065,364	45.9
1963	18,267,384	5,714,746	7,467,842	3,393,066	691,730	6.27	11.02	3,665,962	54.6
1964	17,184,251	5,888,826	7,177,188	3,412,989	705,248	6.11	10.76	3,455,034	58.7
1965	14,865,955	5,296,989	5,938,982	2,929,527	700,457	6.55	11.65	3,246,034	61.3
1966	12,941,264	4,088,144	5,253,408	2,938,095	661,017	6.87	N/A	2,590,547	63.4
1967	12,256,063	3,258,000	4,740,000	3,627,000	631,660	7.21	N/A	1,997,806	61.3
1968	11,460,833	2,450,000	4,696,000	3,709,000	605,920	7.62	N/A	1,475,000	60.2
1969	10,472,916	2,150,664	4,579,000	3,253,000	535,369	7.45	10.06	1,326,598	63.0
1970	9,729,398	1,666,694	4,541,000	3,036,000	409,354	7.10	8.98	1,150,596	66.1
1971	8,727,325	1,245,326	4,450,457	2,492,178	389,609	6.30	8.34	669,691	52.1
1972	7,106,295	944,000	3.492,444	2,202,000	476,792	6.38	N/A	593,997	62.9
1973	6,746,000	702,843	3,284,905	2,305,265	N/A	6.65	N/A	N/A	N/A

Sources: Prepared by Consultant based on data from:

1. Minerals Yearbook (Fuels), U. S. Department of the Interior, Selected Years
2. Annual Report, 1973 Data from the Pennsylvania Department of Environmental Resources, Office of Mines and Land Protection, 1973.

manner. Deep mining, on the other hand, had fallen by 1970 to 18 percent of total output where as recently as 1950 deep mining was the source of over 60 percent of anthracite coal.

As equipment was developed which utilized small sizes of anthracite, dredge and culm (bank) production grew in importance. Much of the preparation plant wastes in the early days of mining was discharged into streams or eroded into watercourses from refuse banks. River beds in the coal region soon became covered with small sizes of anthracite. Suction devices and dewatering screens mounted on barges were introduced to dredge this coal from the water.

Bank production also relies upon the recovery of previously mined coal. Culm, a waste product of early preparation methods, is simply shovelled up and run through the preparation plant or burned directly.

Dredge production has only occasionally exceeded one million tons per year and in 1970 accounted for only four percent of total production. The bank method grew almost fourfold during World War II and reached its peak output of over nine million tons in 1944. In 1970 culm recovery represented 33 percent of total anthracite output.

C.4 Productivity and Mechanization

Annual productivity measures for the industry from 1890 to 1972 have been computed in Table I-6. Productivity, defined here as tons of output per man day, has displayed an upward trend over the last 82 years. Several reasons can be cited for this accomplishment. Generally, the introduction of mechanization into a production process increases the output per man. The steady rise in percent of coal loaded mechanically underground is a single measure of the rise in mechanization in the coal industry. Advances in technology in preparation and production methods will also raise productivity even if more tools are not added to the process. The total efficiency of the process is not measured by this partial productivity analysis but it indicates a direction.

Furthermore, the shift in production from deep mining to strip, dredge, and bank production is a shift from a labor intensive process to a capital intensive process. Such a shift should, and did, occasion an increase in output per man day. The importance of this shift in raising production can be seen by reviewing the labor productivity of bank, strip and deep mining for recent years. In 1971, the productivity of extraction in strip mines was 8.37 tons/man day, culm extraction was even greater at 31.53 tons/man day. This can be compared with a productivity of extraction for deep mines of 4.09 tons/man day. The total labor productivity for the anthracite industry reached a peak in 1969 and has not reached the same level since (Column 7, Table I-6). Partially to blame are the more rigorous environmental, health and safety regulations.

C.5 Production by Field

Anthracite production is broken into the four fields; Northern, Western Middle, Eastern Middle, and Southern in Table I-7. The Northern Field has suffered the greatest relative and absolute decline in production in the last century. The once predominant Northern Field, which accounted for almost 50 million tons of production in 1917, had dwindled to a total production of just over 2 million tons in 1970. The Northern Field owes its decline to a variety of factors. Deep mining has been restricted in this Field by excessive water, and the opportunities to strip the coal are limited by the historic depletion of amenable veins. The greatest reserves of anthracite lie in the Southern Field where production of anthracite in 1970 reached 3.7 million tons. This Field has yielded the greatest volume of anthracite in recent years.

TABLE I-7

TOTAL ANTHRACITE PRODUCTION BY FIELD*

Selected Years 1950-1970

Field	1950	1955	1960	1965	1970
Northern	20,275,284	10,481,822	6,348,253	4,550,780	2,086,000
Western Middle	11,019,176	6,551,139	5,176,725	3,464,190	2,545,000
Eastern Middle	3,085,370	2,358,410	2,121,500	2,026,884	1,511,000
Southern	9,696,875	6,813,184	5,170,963	4,824,101	3,700,000

*Tons

Source: Minerals Yearbook, U. S. Bureau of Mines, Selected Years

C.6 Employment

Accompanying the long term decline in production of anthracite coal has been a steady decrease in employment for Pennsylvania anthracite workers. Employment in the industry reached its peak in 1914 with over 180,000 employees. By 1940 the ranks of anthracite workers had been cut in half. The relative decline became even more rapid until 1970, at which time only 6,000 workers remained in the industry. Table I-8 indicates that by 1973 strip miners outnumbered deep miners for the first time. Dredge and bank employees still represented a small portion of the total in 1973. The total manhours of labor in the industry has also declined more than ten fold in the last two decades.

C.7 Consumption

In the early years of anthracite mining, the markets were limited to Philadelphia, New York and the immediate vicinity of the coal fields. As transportation improved, the markets became more wide spread. The Middle Atlantic States, New England and Canada remained the heaviest users of the coal as shown in Table I-9. In 1970 the Middle Atlantic States alone received 74 percent of the total shipments. Railroads have allowed the lake states, mid west and western states to be the markets of least decline in the last 20 years. In 1972 the western states and Canada received more coal than in 1970. These two regions represent the only areas of growth of anthracite consumption.

Today anthracite coal is used primarily as a fuel for household heating. Before 1910 this was not the case, the clean burning coal was used industrially in foundries, blacksmith shops, and iron and steel production. Early in the 20th Century coke replaced anthracite as the major industrial fuel. At the same time that anthracite was reaching its zenith as a home heating fuel, some railroads also switched from bituminous to anthracite coal. Later in the 20th Century electric power generation became a large market for anthracite coal. Table I-10 shows that space heating (commercial and residential) and electric utilities are the major consumers of the fuel today. Both sources of demand have been declining, however. In 1972, retail delivery of coal amounted to slightly less than three million tons and electric utilities consumed 1.6 million tons. The combined demand represented 4.5 million tons of anthracite, which is 36 percent less than the demand of a decade earlier. In the 1960's only cement plants and the steel industry have shared a steady or increasing demand for anthracite coal. In 1969 these two consumers received 13 percent of the total output.

C.8 Causes for Industry Decline

The decline in Pennsylvania anthracite production since 1917 is primarily the result of a competitive disadvantage in prices compared with other energy sources. Characteristics unique to the anthracite industry

TABLE I-8

ANTHRACITE EMPLOYEES BY COUNTY[1]

Pennsylvania Anthracite Region
1973

County	Deep	Bank	Strip	Breaker and Washery	Total Employees
Carbon	-	5	39	-	44
Columbia	22	-	2	-	24
Dauphin	18	6	-	26	50
Lackawanna	-	6	175	70	251
Luzerne	230	78	562	473	1,343
Northumberland	70	28	190	184	472
Schuylkill	396	201	655	590	1,842
Sullivan[2]	-	-	10	11	21
Susquehanna	-	3	-	3	6
Region Total	736	327	1,633	1,357	4,053

[1]Dredge employees excluded.
[2]Semi-anthracite production.

Source: Annual Report, Pennsylvania Department of Environmental Resources, 1973, p.109.

TABLE I-9

DISTRIBUTION OF PENNSYLVANIA ANTHRACITE*

Domestic and Foreign
Selected Years 1950-1972

Region	1950	1955	1960	1965	1970	1971	1972
New England	3,705,810	1,813,588	944,121	406,305	126,390	104,491	89,132
Middle Atlantic	30,442,451	19,785,414	14,812,945	10,517,403	7,085,771	5,889,685	5,529,626
South Atlantic	1,102,554	665,690	532,765	454,755	162,727	133,394	102,105
Lake States	1,468,692	817,650	635,151	456,313	522,119	485,946	355,392
Other States	170,820	281,311	276,698	324,470	308,951	424,732	448,715
Total U.S.A.	36,890,327	23,363,653	17,201,680	12,159,246	8,205,958	7,038,242	6,524,970
Canada	3,625,373	2,305,024	1,382,455	506,379	358,410	443,783	418,262
Other Countries	1,040,315	817,580	228,664	1,619,402	1,002,513	1,089,501	898,595
Total	41,556,015	26,486,257	18,812,799	14,285,027	9,566,881	8,571,532	7,841,827

*Tons

Source: Minerals Yearbook, U. S. Bureau of Mines, Selected Years.

43

TABLE I-10

CONSUMPTION OF PENNSYLVANIA ANTHRACITE BY CONSUMER CATEGORY*

United States
1955 - 1972

Year	Retail Delivery	Colliery Fuel	Railroads	Electric Utilities	Briquette Plants	Cement Plants	Iron & Steel Industry: Coke Making	Iron & Steel Industry: Sintering & Pelletizing	Other
1955	13,019	419	457	3,209	264	199	366	385	443
1956	13,018	342	409	3,296	228	244	377	564	625
1957	10,670	279	361	3,363	156	221	389	868	698
1958	9,386	195	335	2,786	120	183	255	685	686
1959	7,562	129	292	2,629	43	159	369	780	683
1960	6,775	102	248	2,751	31	152	370	754	720
1961	5,070	45	-[1]	2,509	28	153	320	588	685
1962	4,767	152	-	2,297	-[2]	188	420	560	609
1963	4,055	161	-	2,155	-	184	451	766	670
1964	3,334	144	-	2,239	-	153	492	1,014	-
1965	3,126	143	-	2,158	-	269	507	966	2,229[3]
1966	5,622[4]	141	-	2,192	-	187	515	897	1,846
1967	5,035	143	-	2,186	-	239	528	819	1,850
1968	4,759	56	-	2,203	-	281	532	748	1,681
1969	4,209	17	-	1,849	-	213	543	623	1,355
1970	4,042	16	-	1,897	-	-[5]	472	464	1,357
1971	3,850	15	-	1,646	-	-	421	339	1,037
1972	2,960	11	-	1,584	-	-	474	283	603

*(1,000 Net Tons)

[1]Railroads no longer listed as a separate category after 1960.
[2]Briquette plants no longer listed as a separate category after 1961.
[3]Classification "Other" becomes more comprehensive in 1965.
[4]Classification switched in 1966 to "Residential Commercial Heating".
[5]Cement plants no longer listed as a separate category after 1969.

Source: Minerals Yearbook, U. S. Bureau of Mines, Selected Years.

have precipitated the falling market demand. The culprits to the industry range from management, labor and transportation constraints to unfavorable legislation, the nature of the mineral anthracite, and its geologic location.

Harold Aurand cites overinvestment as the industry's basic weakness.[1] In the latter part of the 19th Century, capital costs for opening mines began to soar. Railroads, with their access to money markets, soon gained control of coal operations. By 1925, seventy-five percent of the tonnage being mined was controlled by the railroad companies in the area. The mines in this period were constructed without regard to optimal long run size but rather with an eye to the need for immediate rail freight.

When the Supreme Court broke up the railroad monopoly and divestment followed, in 1926 the Anthracite Coal Industry Commission found that freight rates became discriminatory against anthracite as opposed to bituminous coal. As early as 1915 the Interstate Commerce Commission had found freight rates to be excessive for the anthracite industry. In a report of the Pennsylvania Anthracite Coal Industry Commission[2] in 1938 the freight rates for selected shipping distances are compared between anthracite and bituminous coal. The unweighted average miles per shipment of bituminous coal was 377 miles at a cost per ton mile in 1937 of 0.825 cents. The anthracite rate for an unweighted average trip of 291 miles came to 1.237 cents per ton mile in 1937.

Organized labor chipped still more away from anthracite's competitive position. The strike during the winter of 1925-26 led some consumers to search for more dependable supplies of fuel. Also, as the United Mine Workers' bargaining strength increased, they demanded the "equalization of work time" rule. Management was thus faced with operating mines three and four days a week at prohibitive costs. Finally, by 1959, the anthracite health and welfare payments had risen to seventy cents per ton, opposed to only 40 cents per ton in the bituminous industry.

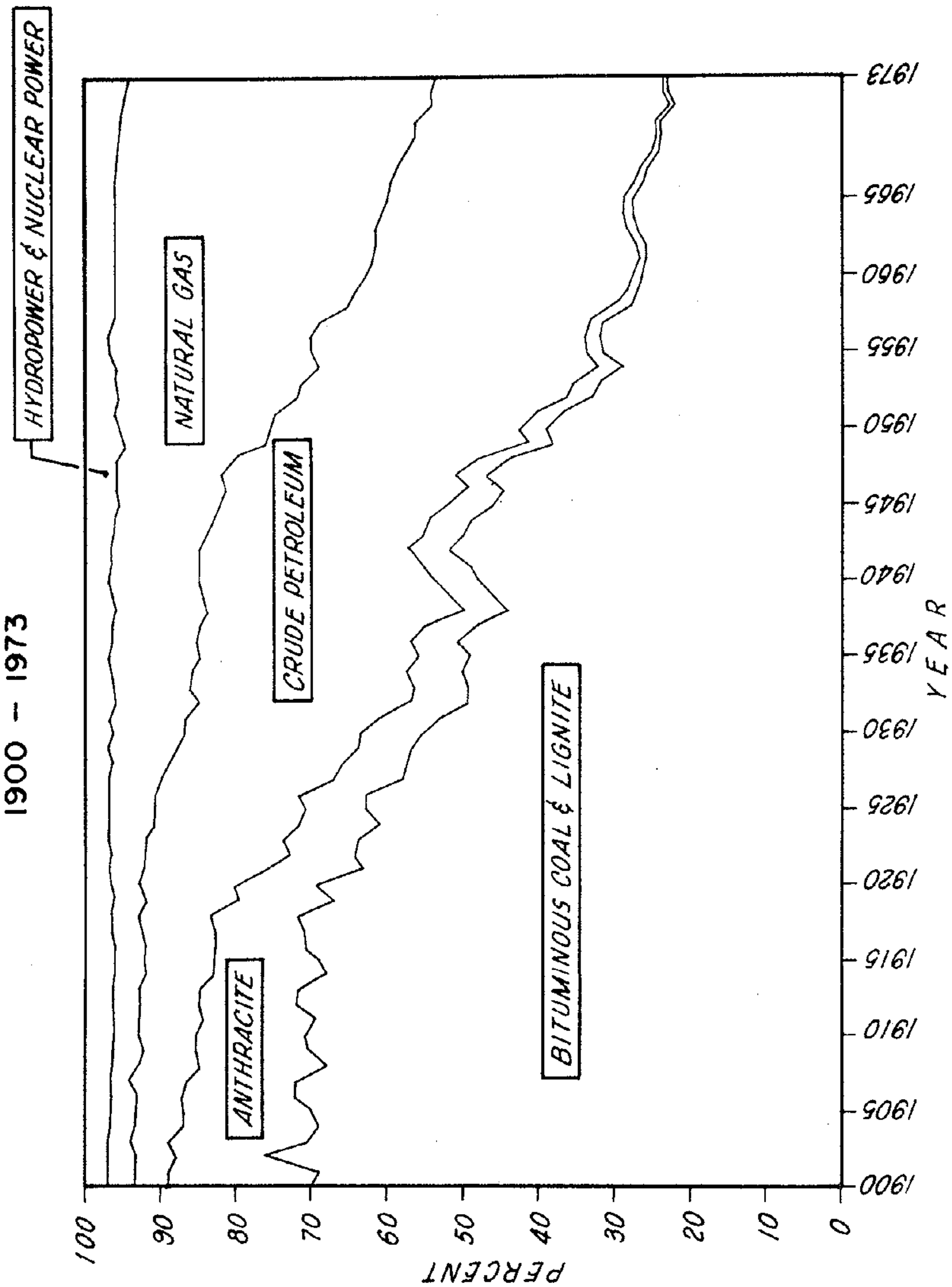
Aside from the internal difficulties of the industry, the nature of the product must also be considered. Plate I-3 portrays the relative 20th century production of British Thermal Units of energy in the continental United States from mineral and hydropower sources. The role of coal as an energy source has declined severely from almost 90 percent of the energy output to less than 20 percent in 1970. The anthracite industry first lost most of its industrial market to bituminous coal early in the 20th

---

[1]H. Aurand, From the Molly Maguires to U.M.W., Temple University Press, Philadelphia, 1971, page 93.

[2]Report of the Anthracite Coal Industry Commission, Pennsylvania Anthracite Coal Industry Commission, June 30, 1938, pages 564-5.

DISTRIBUTION OF ENERGY PRODUCTION
CONTINENTAL UNITED STATES
1900 - 1973



SOURCE: Prepared by Consultant based on Data from the U.S. Dept. of Interior, Bureau of Mines, Minerals Yearbook, Selected Years

PLATE I - 3

Century and then lost a share of the space heating market to oil and gas partially because of the inconvenience of coal heat. Consumers preferred not to shovel, stoke or store coal once gas and oil became available.

The competitive position of anthracite was additionally eroded by the geological features of the area which hindered the application of cost reducing technologies and large scale operations. The majority of anthracite remains too inundated or too deep underground for stripping operations. The overburden of sandstone and shale, the steep pitches of the coal seams, and the hardness of the coal all reduced the role of cost cutting mechanization in the industry.

Finally, state and federal mining laws regulating the anthracite industry have been in some respects restrictive.

A recent example is the Federal Coal Mine Health and Safety Act of 1969. The standards for ventilation, hoists and automatic couplers established by this law have been burdensome to marginal deep mines. The sudden capital expenditure necessary for compliance was enough in many cases to foreclose the operation.

The combined forces of market competition as well as management, labor, production, transportation, and legal constraints proved too awesome for the anthracite industry. As the market price for anthracite lost its sweetness and demand evaporated, new fuels stood ready to fill the energy void.

CHAPTER II - SUMMARY

THE INDUSTRY TODAY - PRODUCTION AND DISTRIBUTION

A. MINING METHODS AND FACILITIES

Deep mines are usually slope or drift mines, and the traditional "gangway, chutes and heading" method of extraction is the most common. Innovations include "longhole" and "slant chute" production. There is little mechanization.

Strip mining is performed by blasting the rock overburden and removing the fractured material and coal with a dragline, power shovel or front-end loader.

Culm banks are usually recovered with a front-end loader. Several streams are still dredged for coal fines.

Preparation plants are mostly pre-1950 vintage, and designed to process local coal. Heavy media separation is the most popular method of cleaning coal. Anthracite is marketed in ten sizes.

B. ORGANIZATIONAL STRUCTURE

1973 PRODUCTION - THOUSANDS OF TONS				
	Deep	Strip	Culm	Total
Southern Field	442	1,139	1,062	2,643
Western Middle Field	90	594	656	1,340
Eastern Middle Field	4	865	424	1,293
Northern Field	167	687	163	1,017
Totals	703	3,285	2,305	6,293

In 1973, there were 189 anthracite operators. The Reading Company's production of 758,000 tons led the industry. The top twenty companies produced 71 percent of total output. Productivity of all modes of production was generally substantially higher in the larger organizations, the best averages among various groupings of firm sizes were:

Deep Mining 6.4 tons per man day
Strip Mining 10.8 tons per man day
Culm Banks 67.4 tons per man day

In December 1974, the Greenwood Stripping Corporation was purchased by the Bethlehem Steel Company, thus becoming the only "captive" anthracite mine.

C. LABOR

The anthracite industry labor force numbered 4,783 in 1972. In 1973, 936,000 man days were worked, 377,000 of these in the Southern Field; 44 percent of the man days were in stripping, 33 percent in preparation processes.

Several training programs have been offered since the inception of the Manpower Development Training Act, 1962.

Over half the anthracite workers are members of the United Mine Workers of America. The average age of union anthracite workers was estimated at 45 in 1974. Payments to the Anthracite Health and Welfare Fund were 90 cents per ton in 1974.

The other major labor groups are the Independent Miners and Associates and the Independent Miners, Breakers and Truckers Association.

In 1954, anthracite and bituminous workers earned the same average hourly wage. In 1972, the figures were $3.71 and $5.34 respectively. However, the anthracite worker receives substantially better pay than the average manufacturing worker in the region.

D. INDUSTRY COSTS

In 1972, the average cost for producing a ton of anthracite was $13.32, compared with $7.94 for bituminous coal. Labor was the largest single component at $4.95 per ton of anthracite, and was a substantially higher proportional cost for deep mining than for strip mining.

Special factors influencing the costs of anthracite are: the necessity for substantial pumping; the consequent treatment costs of these large volumes of water; the hard rock overburden that has to be removed for stripping operations; and the archaic deep mining methods.

The minimum bond required for reclaiming stripped anthracite land is $1,000/acre. Assessments for "Black Lung" payments are currently being negotiated between the state and the operators.

One estimate for the development of a 25,000 ton per year deep mine is $250,000. Large scale strip operations can require over $10 million investment. Some of the larger draglines cost over $5 million each.

Capital for expansion is a problem, which should be alleviated when renewed confidence in the industry is generated.

E. TRANSPORTATION

Twenty-four percent of anthracite shipments remain in the region, 71 percent within the states of Pennsylvania, New Jersey and New York. The great bulk of exports (16 percent of 1973 production) is via Baltimore and Philadelphia.

In 1973, 57 percent of anthracite was shipped by truck, 43 percent by rail. The truck percentage increased from 18 percent in 1950.

Five of the six major railroads serving the region are in bankruptcy proceedings. In 1973 the Reading Railroad carried 55 percent of the anthracite shipped by rail, or 2.2 million tons. Considerable deterioration in the equipment, infrastructure, and service of the railroads is apparent. A shortage of hopper cars is frequently experienced.

There is considerable concern in the State that the 1973 Regional Rail Reorganization Act could result in the abandonment of critical tracks and rights of way, causing several mines to cease operations.

The volume of anthracite shipped to any one destination is too small to warrant unit trains, thus this opportunity to reduce freight costs is not available. Average anthracite and rail rates have doubled since 1965, while bituminous rates have declined 14 cents per ton.

Truck transportation has been helped by the opening of a good network of Interstate highways to supplement the older Turnpike.

Railroads are more efficient land users, taking only seven percent of that needed for a major highway right of way. If anthracite production increases, both modes will have to share the bigger load.

F. LEGISLATION

The President is seeking amendments to acts so as to encourage a greater use of coal. Acts currently having the most effect on anthracite mining include:

Federal Energy Administration Act of 1974. Oil and gas use is to be reduced in favor of coal.

Energy Supply and Environmental Coordination Act of 1974, prohibiting major coal burning installations from converting to oil or gas.

Clean Air Act of 1965 (with amendments). Pollutant emission limits would favor use of anthracite.

Energy Reorganization Act of 1974, establishing Energy Research and Development Administration, will encourage development of new fuel technology.

Non-Nuclear Energy Research and Development Act of 1974 should encourage coal development.

Federal Coal Mine Health and Safety Act of 1969 establishes requirements that are difficult for anthracite operators to meet, specifically those relating to ventilation, electrical wiring and hoisting equipment.

Pennsylvania Anthracite Coal Mine Act of 1965 has some conflict with requirements of Mine Enforcement and Safety Administration, also problem with roof bolting requirements.

Pennsylvania Clean Streams Law of 1970, prevents pollution of watercourses.

Pennsylvania Surface Mining and Reclamation Act of 1971 requires restoration of the land to original or acceptable contours. Requirement that highwall does not exceed 35 degrees difficult to meet in steeply pitching anthracite beds.

Pennsylvania Air Pollution Control Act, 1968 (amended 1972) establishes parameters for permissible air pollution. Requirements for sulphur dioxide emission would favor use of anthracite.

At some point in the seam, a gangway is driven right and left of the tunnel or slope. At predetermined intervals chutes are driven up pitch to connect with a parallel entry or monkey heading. These chutes serve the dual purpose of providing an efficient means of ventilating and as a loading chute for coal extracted further up pitch.

Many methods exist for pitch coal mining, depending on the angle of inclination, firmness of seam, and competency of underlying and overlying strata. The extraction of anthracite on pitching seams has led to the development of many patterns, which are followed to this day (see Plates II-1, II-2, and II-3). The design usually adopted is to determine the required lift and apply one of several methods for winning the pitching seams. On moderate pitches and thicknesses, the full seam is excavated to such widths as roof and bottom conditions allow. These pitching entries, or breasts, may be driven with the pitch or slanted. At selected intervals, parallel breasts are driven and interconnected by a series of headings. The pillars separating the breasts will be won by splitting or skipping.

Heavy pitching seams are similarly driven, but require a platform on which men can safely work. This is accomplished by containing most of the mined anthracite within the excavated breast. Travelways are provided along the ribs for access to and ventilation of the face area. Excess anthracite, from the developing face, is channeled through the travelways to a loading chute at the gangway level.

Innovations which have reduced the effort and make deep mining more efficient include "longhole" and "slant chute" production. Longhole mining is essentially a recovery method used in conjunction with conventional mine development. Two methods are widely used. One requires the use of conventional pitching entries to provide access to the separating pillars. A series of long holes are drilled into the pillar and charged. The fractured mass is loaded from the breast chute. The second method requires access to a long face by either a breast heading or an airway heading. Long holes are drilled in a fan-like pattern and charged. Under ideal conditions, complete recovery of the seam and minimal exposures to the usual mining hazards can be expected.

The slant chute technique of mining (Plate II-4) provides an additional gain in safety and efficiency where seams are steeply pitched. This method allows mining at a more workable angle. The reduced slope is achieved by driving diagonally across the pitch at grade angles necessary for material flow.

Aside from some experimental work, underground mechanization in anthracite mining is limited to loading and haulage. Table II-1 reveals the present mix of machinery employed in loading . Scraper loaders are used to handle the greatest volume of coal. In 1972, only eleven mobile loaders were used in the entire industry. Mechanical miners which have

CHAPTER II

PRODUCTION AND DISTRIBUTION

A. MINING METHODS AND FACILITIES

The historic reliance on deep mining as a major source of anthracite coal has been altered by technological advances in surface excavation equipment. The source of today's coal has shifted from deep mining to strip, culm bank and stream recovery. Each approach to mining requires a separate technique and mix of labor skills and capital equipment.

A.1 Deep Mining

All deep mined coal in the Pennsylvania Anthracite Region is produced by methods established by traditions which can be traced to the industry's origin. The steep pitch of anthracite veins requires special approaches. Four types of entries are used and are defined as follows:

1. Drift Entry

When the topography allows sufficient lift, a water level entry is excavated at a low point in the crop line. The drift entry follows the seam on a rising grade sufficient to allow for the gravity flow of mine water. The drift entry also serves as the developing gangway.

2. Tunnel Entry

As the name implies, a horizontal entry is driven into and through the overlying or underlying rocks to intersect a seam or seams. As with a drift entry, a tunnel entry is driven on a slight rising grade.

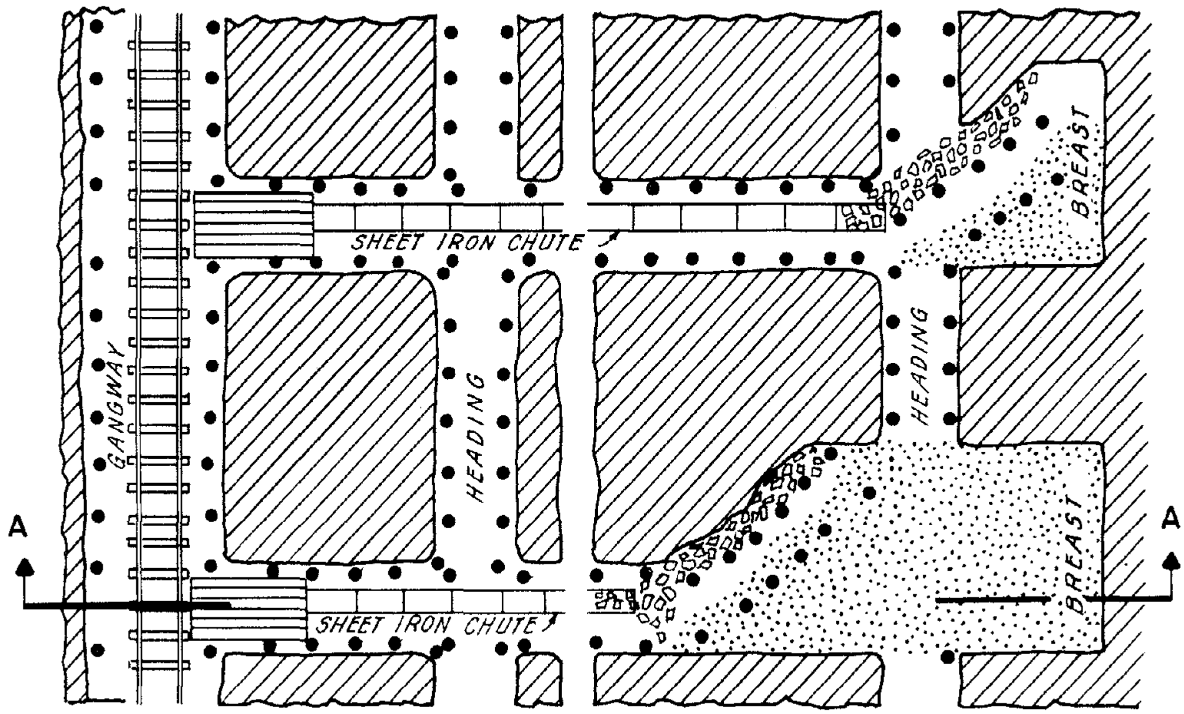
3. Slope Entry

Following the pitch of the seam to the dip is the usual practice. The entry may be at right angles to the strike or deviating to the right or left. Because of the absence of suitable areas for drifting, and the expense of tunnel driving, slopes are the dominant means of entry.

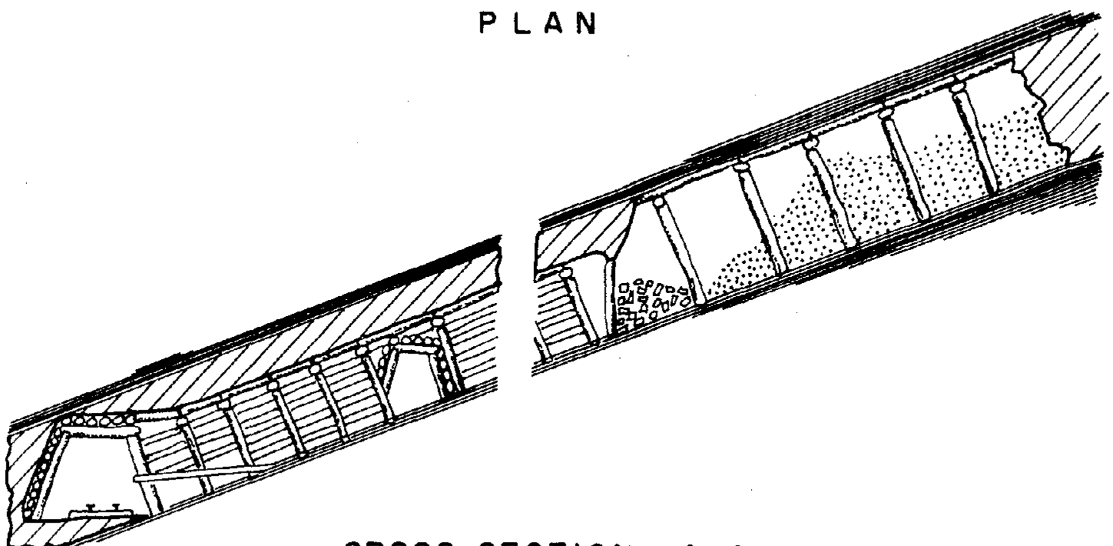
4. Shaft Entry

The shaft is a vertical excavation driven to intersect a coal seam at depth.

METHOD OF WORKING BREASTS
(MODERATE PITCH)



PLAN

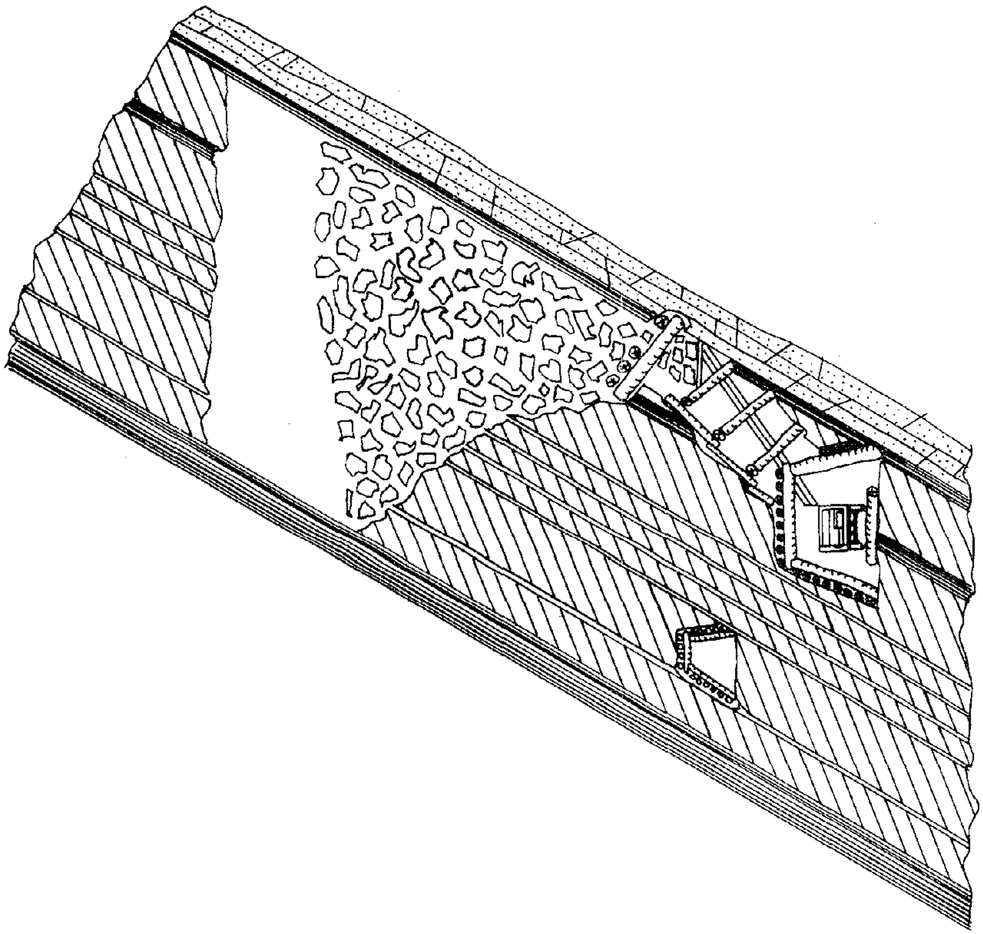


CROSS SECTION A-A

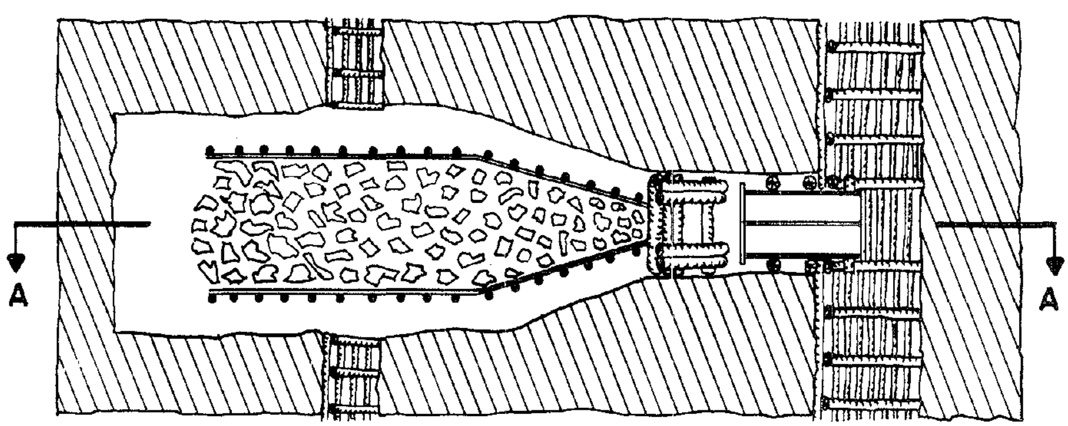
SOURCE: Pa. Second Geological Survey, 1883

PLATE II - 1

METHOD OF WORKING BREASTS
(STEEP PITCH)

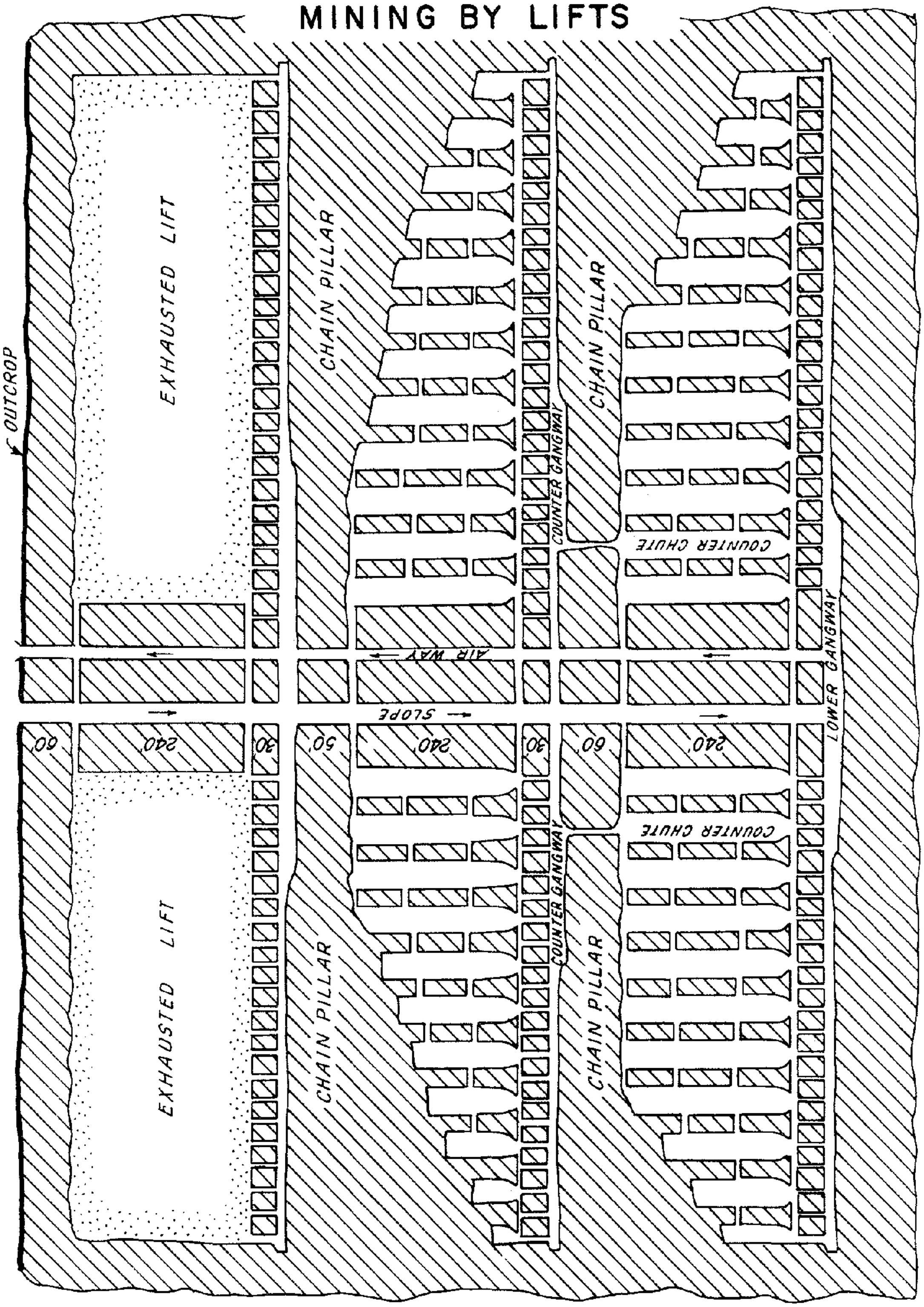


SECTION A-A



SOURCE: Pa. Second Geological Survey - 1883

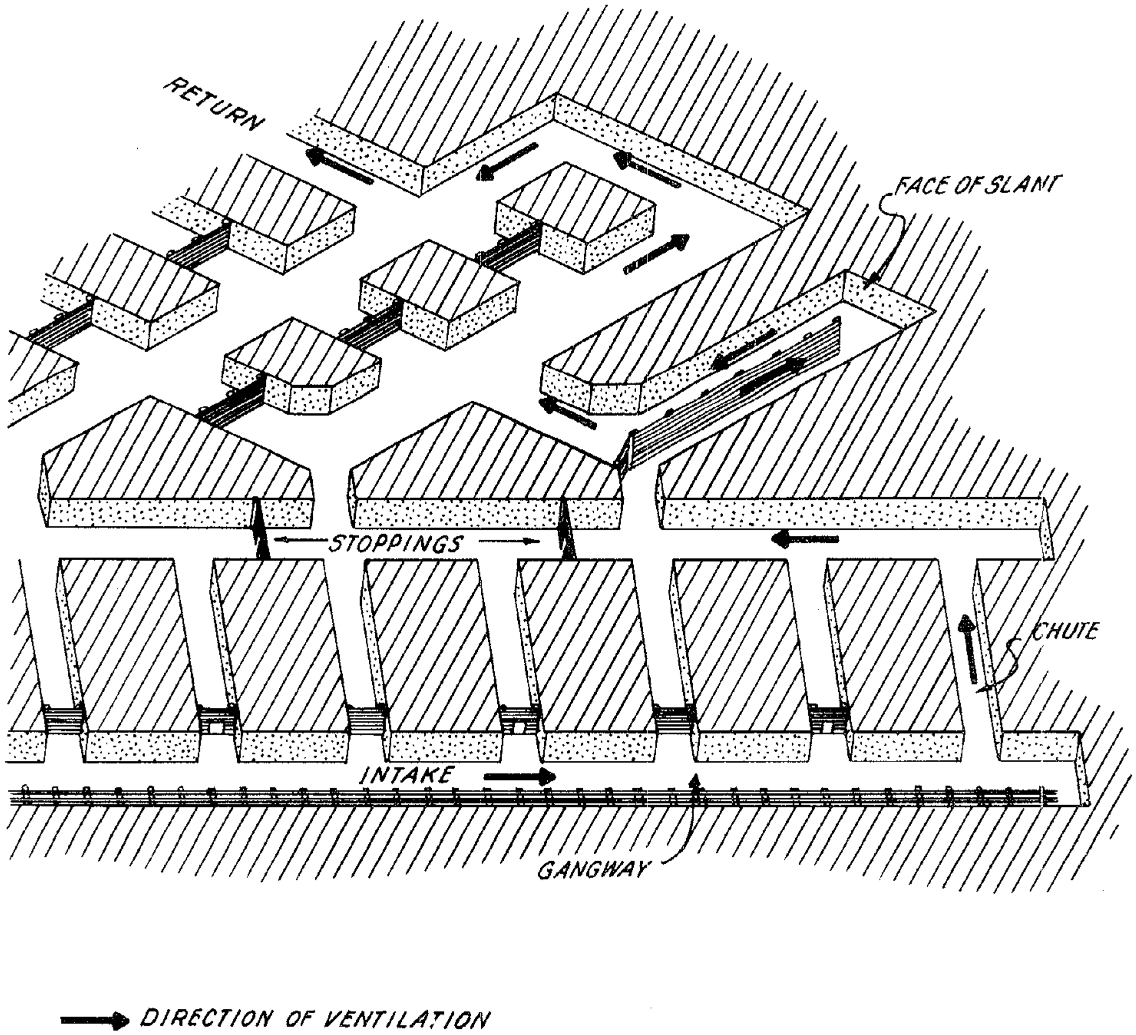
MINING BY LIFTS



SOURCE: Pa. Second Geological Survey - 1883

PLATE II - 3

SLANT MINING
(OFF LEVEL ENTRIES)



SOURCE: A. B. RIEDEL, P.E.

PLATE II - 4

TABLE II-1

PENNSYLVANIA ANTHRACITE LOADED MECHANICALLY UNDERGROUND

(Thousand Short Tons)

Year	Scraper Loaders		Mobile Loaders		Conveyor[1] and Pit-Car Loaders		Total[2] Loaded Mechanically	
	Number of Units	Quantity Loaded	Number of Units	Quantity Loaded	Number of Units	Quantity Loaded	Number of Units	Quantity Loaded
1968	131	710	26	121	184	643	341	1,475
1969	106	567	25	190	158	570	289	1,327
1970	103	491	20	183	147	476	270	1,151
1971	95	319	18	151	91	199	204	670
1972	81	347	16	136	46	111	143	594

[1]Includes duckbills and other self-loading conveyors.
[2]Data may not add to totals shown because of independent rounding.

Source: *Minerals Yearbook*, U. S. Bureau of Mines, 1972, p.411.

been successfully applied in retrieving bituminous coal have not been suitably developed to mine the steeply pitched anthracite veins.

The transporting equipment varies from conveyor belts and chain conveyors to locomotives and rolling stock within the haulageways. Lifting equipment in the shafts and slopes are primarily of the drum hoist or winch type.

A.2 Strip Mining

Anthracite strip operations vary from shallow excavations along the outcropping limbs to the complete removal of synclinal troughs extending hundreds of feet below the surface and covering many acres of land. Four separate operations are required in strip mining today:

1. Drilling and blasting the overburden
2. Removal of the overburden
3. Coal extraction
4. Backfilling.

The drilling is normally done using a blast hole drill rig which may be truck mounted or self propelled. One of the more common drills is a diesel powered rotary type which will normally be used to sink holes 30 to 60 feet deep. Soft rock can be penetrated at a rate of 800 to 1,000 feet of hole per shift.

After fracturing the overburden along pre-drilled blasting patterns, the rock is then removed either by draglines, power shovels or front end loaders. Each unit has its own special advantages. A dragline can handle the larger rock fragments, reach into inaccessible steeply pitched areas, retrieve debris from inundated areas, and permit direct casting of the overburden. It is, however, extremely expensive, and somewhat immobile (especially the larger walking unit).

The power shovel has more digging and lifting power than the dragline and has a somewhat faster truckloading cycle. At the same time, the maneuvering and positioning of the equipment is more crucial than that of the dragline. Power shovels are more efficient when operating on a flat terrace and situated such that the bucket can be filled by gravity and the overburden placed directly into the holding unit. The selection of power shovels also sacrifices mobility in the interest of lifting power and bucket stability.

The front end loader most commonly used is an articulated wheel mounted unit. The lifting capability of these units ranges up to 20 yards of material at a time. A special advantage is realized by the combination of superior lifting power and mobility. The front end loader is most efficient when the material being loaded is either loose, finely blasted, or in a bank condition. For optimal utilization the overburden must be drilled and blasted at closer intervals. Because the front end loader can operate at close quarters it has been extensively adopted by strip miners.

Any of the aforementioned vehicles are suitable to extract coal once it has been fractured for handling. Equipment selection must, however, be coordinated with the requirements for removing overburden. Throughout the entire anthracite mining industry in 1972 there were 118 draglines, 103 front end loaders, and 60 power shovels in use. Some of this equipment was not dedicated solely to strip mining, since similar operational techniques are required in culm bank recovery.

To backfill, both the front end loader and crawler mounted draglines are suitable for moving material. In addition, if the terrain permits, both the bulldozer (crawler or wheel mounted) or the scraper-loader can be used effectively.

A.3 Culm Bank Recovery

Culm banks contain the accumulated waste products from coal preparation plants. Early burning equipment was not designed for finer size coal. As new markets for smaller sizes have grown, previous waste material can simply be loaded into trucks and hauled to a preparation plant for processing. Some culm banks used by the utility companies are adaptable to existing boilers and require no processing.

To recover the culm bank coal the power shovel, front end loader, or smaller crawler-mounted draglines are used. The selection of equipment is again based upon the judgment of the operator in relation to the nature and location of the bank material.

A.4 Dredge Coal

The beds of waterways which drain the Anthracite Region became covered by substantial amounts of anthracite in the early days of mining. Before the introduction of environmental regulations, preparation plants discharged waste directly into streams. In addition, naturally eroded coal and silt material collected in the Susquehanna, Schuylkill and Lehigh Rivers, as well as their tributaries.

Dredge coal is siphoned from the river bed by rotary pumps installed in dredge barges. In most cases the coal can be prepared on board prior to docking. As dredging operations follow the silt slowly downstream the recovery is not confined to the anthracite reserve area. In 1972, dredging occurred in Berks, Lancaster and Snyder Counties, in addition to the counties in the Anthracite Region.

A.5 Preparation Plants

Most anthracite preparation plants were constructed prior to 1950. The larger plants have been modernized although the bulk of the new equipment is often material that has been salvaged from abandoned plants elsewhere. The industry currently has two types of preparation plants - those that handle coarse coal, and those that process the finer particles.

Because the washability characteristics of coal varies among veins, or even among locations within the same vein, each preparation plant must constantly monitor its cleaning process in order to provide a salable coal. Adjustments to the crushers, screens, and the specific gravity of the separating media determines the size and quality of the products for a particular plant.

A.5.a Cleaning

The 30 largest preparation plants have a variety of coal washing units.[1] The most commonly employed facilities include:

1. Heavy media separators
2. Hydrotaters
3. Mechanical classifiers
4. Cyclone classifiers
5. Cone cleaners

Heavy media separation is the most advanced and popular method of cleaning coal. Crushed coal is fed to a vessel containing a mixture of finely ground magnetite and water. The mixture maintains a specific gravity upon which the coal will float and the heavier refuse will sink to a sump for removal to the culm bank.

The hydrotator is a form of classifier designed especially for anthracite and was introduced in 1925.[2] It was designed to clean coal sizes larger than the Buckwheat No.5 and as an additional factor, can be used for thickening. An agitator, suspended in a tank and supplied with water under pressure, creates an upward current. The material is fed into the tank and the fines are permitted to go into suspension. A density is created which will float coal of either a desired size or specific gravity. Once the coal is "classified" it is removed at the surface and heavier refuse material collects at a sump.

---

[1] Keystone Coal Industry Manual, McGraw-Hill, Inc. 1974.

[2] D. R. Mitchell, Coal Preparation, Seeley W. Mudd Series, 1943.

A classifier is a more specialized cleaning unit that processes fine materials used for industry (Buckwheat No.5 coal). In the classifier a coal-water mixture is introduced into a tank in which the mixture is agitated and circulated to create an upward current. The lighter coal is held in suspension and drained off. The heavier refuse settles to the bottom and is transported by a conveyor to a disposal area.

Further classification may be accomplished using a froth unit operation. One particular system is designed to extract the finer Buckwheat No.6 coals, which were previously discarded.[1] A somewhat dry coal is introduced to a circulating oil and water bath where the coal particles are mixed with air bubbles and rise to the surface with the oil froth. The coal is then continuously skimmed off by a scraping mechanism and dewatered.

The cyclone classifier has no moving parts and uses a recirculating water system to clean the fine coals. The uses can be quite flexible, it can serve as a wet classifier or a density separator.[2] The feed (averaging one-eighth to three-eighths inches) is normally introduced under pressure into a vertical chamber where a cyclonic water action creates a vortex. The fine material (including pyrites) then collect at the vortex and are drawn off for further separation. The coal is removed at the cone apex (located at the cyclone's lowest elevation) where it is then dewatered. Depending on its size a cyclone can classify coal from 28 to 300 mesh.

The cone cleaners are supplied by a variety of manufacturers, and are generally used to clean the larger domestic size coals. The coal is mixed with water, agitated into suspension, and then carried off the dewatering and sizing screens.

Currently, there is only one concern remaining in the Region that engineers and designs anthracite preparation facilities. Most of the newly installed equipment is from other material processing systems.

A.6 Sizing

The marketable coal is sized at the preparation plant as it is gravity fed through a variety of screening devices. There are ten sizes of anthracite coal sold, as listed in Table II-2. The sizes range from broken coal which screens through four and three-eighth inch mesh, to Buckwheat No.5 which is three-sixty-fourth inches or less. The Anthracite Committee

---

[1]Wilmot Preparation Equipment, Bulletin CC-552, Wilmot Engineering Company, White Haven, Pennsylvania.

[2]Joseph W. Leonard, SME Mining Engineering Handbook, Vol.2, p.27-54.

TABLE II-2

STANDARD ANTHRACITE SPECIFICATIONS

United States
As of 1947

Size	Round Test Mesh (Inches)	Percent					
		Oversize Maximum	Undersize		Maximum Impurities[1]		
			Maximum	Minimum	Slate	Bone	Ash[2]
Broken	Through 4-3/8	-	-	-	1½	2	11
	Over 3¼ to 3	-	15	7½	-	-	-
Egg	Through 3¼ to 3	5	-	-	1½	2	11
	Over 2-7/16	-	15	7½	-	3	11
Stove	Through 2-7/16	7½	-	-	2	3	11
	Over 1-5/8	-	15	7½	-	-	-
Chestnut	Through 1-5/8	7½	-	-	3	4	11
	Over 13/16	-	15	7½	-	-	-
Pea	Through 13/16	10	-	-	4	5	12
	Over 9/16	-	15	7½	-	-	-
Buckwheat No.1	Through 9/16	10	-	-	-	-	13
	Over 5/16	-	15	7½	-	-	-
Buckwheat No.2 (Rice)	Through 5/16	10	-	-	-	-	13
	Over 3/16	-	17	7½	-	-	-
Buckwheat No.3 (Barley)	Through 3/16	10	-	-	-	-	15
	Over 3/32	-	20	10	-	-	-
Buckwheat No.4	Through 3/32	20	-	-	-	-	15
	Over 3/64	-	30	10	-	-	-
Buckwheat No.5	Through 3/64	30	No Limit		-	-	16

[1]Minor exceptions are allowed under special circumstances. Slate is defined as any material that has less than 40 percent fixed carbon. Bone is defined as any material that has 40 percent or more, but less than 75 percent fixed carbon.

[2]Ash determinations are on a dry basis.

Source: Minerals Yearbook, U. S. Bureau of Mines, 1972, p.397.

TABLE II-3

PERCENT OF ANTHRACITE PRODUCTION BY SIZE

Pennsylvania Anthracite Region
Selected Years 1950-1972

Size/Year	1950	1955	1960	1965	1970	1971	1972
Egg	3.5	1.4	0.6	2.9	2.1	2.1	1.1
Stove	18.1	19.8	12.8	12.1	10.3	11.1	11.0
Chestnut	22.4	21.3	16.9	14.1	12.7	11.2	11.4
Pea	7.9	8.3	11.6	10.0	9.3	9.2	8.5
PEA OR LARGER	52.1	51.0	42.0	39.0	34.4	33.6	32.0
Buckwheat #1	14.6	11.7	13.3	12.2	11.8	11.8	11.2
Buckwheat #2 (Rice)	8.6	7.9	9.2	9.7	9.4	9.3	9.1
Buckwheat #3	11.9	10.9	11.8	11.0	12.2	11.6	11.3
Buckwheat #4	6.2	6.9	5.5	5.4	6.6	7.4	8.0
Buckwheat #5	*	3.4	8.6	10.5	11.8	14.6	16.1
Others	6.6	8.2	9.6	11.3	13.8	11.7	12.3
BUCKWHEAT OR SMALLER	47.9	49.0	58.0	61.0	65.6	66.5	68.0

*In 1950 Buckwheat #5 was not listed as a category
39.6 Percent decline of Pea or Larger 1950-1972
26.9 Percent decline of Buckwheat or Smaller 1950-1972

Source: Minerals Yearbook (Fuels), U.S. Bureau of Mines, Selected Years adopted the current standard specifications for processed anthracite in 1947. The standards include limits on size, variations and impurities.

Pea or larger sizes of anthracite (domestic) accounted for 32 percent of the marketable product in 1974 (Table II-3). The industrial sizes (Buckwheat No.1 or smaller) have grown in popularity since more sophisticated furnaces and equipment became available. The relative increase in culm bank recovery has also augmented the production of smaller sizes relative to domestic coal. As a result, in the period from 1950 to 1972, pea and larger production declined 30.6 percent, while industrial sizes declined by a lesser 26.9 percent.

B. ORGANIZATIONAL STRUCTURE

B.1 Production

Total anthracite production for the year 1973 reached 6.7 million tons.[1] The bulk of the output came from strip and culm bank operations. The combined volume of deep and dredge coal amounted to less than 1.5 million tons. The production levels through October, 1974 are slightly below those for the same period in 1973. Output has declined by 10.2 percent and only bank operations have managed to increase their output (4.9 percent) in 1974 (Table II-4).

TABLE II-4

COAL PRODUCTION STATISTICS
Pennsylvania
(Through October) 1973, 1974

ANTHRACITE (Tons)	1973	1974	% Change
Deep Mine	578,991	522,047	- 9.8%
Strip	2,875,140	2,310,622	- 19.6%
Bank	1,902,773	1,977,099	+ 4.9%
	5,356,904	4,809,768	- 10.2%

Source: "Anthracite Accumulative Survey, Comparative Analysis to Previous Year", Pennsylvania Department of Environmental Resources, January, 1975.

[1]Mineral Industries Survey, U. S. Bureau of Mines, "Pennsylvania Anthracite Weekly", March 29, 1974.

B.2 The Producing Unit

The 189 anthracite operations[1] in 1973 displayed a wide range of production capacities and organizational arrangements. The anthracite industry includes small independent underground mines with a couple of employees, as well as the largest three companies which were able to produce 28 percent of all the industry's coal (see Table II-5), and employ hundreds of workers. Small operations frequently involve a single mine or surface location and the raw coal in these cases is usually sold to a breaker or washery. Large companies had, in 1973, as many as 27 production sites and preparation plants. Extraction totals by many companies crossed freely over the categorical boundaries of strip, deep and bank production. The larger companies were able to internally process their raw coal as well.

The corporate structure of large companies is very complex, with quasi-independent operations to provide various functions. As an example, three operations (two of which are listed in Table II-5) are reported as separate companies in the production figures by the Pennsylvania Department of Environmental Resources, yet all three fit comfortably under the title of Pagnotti Enterprises.

As of 1970, there were no "captive" mines in the anthracite industry. The vertical integration of industries has, however, encroached upon the producing operations since then. In December, 1974, the Bethlehem Steel Company purchased the fourth largest anthracite concern - the Greenwood Stripping Corporation, whose output in 1973 totalled nearly 350,000 tons. Greenwood thus became the first captive mine in recent anthracite history.

B.3 Concentration of Output

The Reading Company amassed the greatest output for a single firm in 1973. Reading's 758,000 tons of coal represented twelve percent of all anthracite production for the year. The top twenty anthracite companies listed in Table II-5 combined to produce 81 percent of all output. This pattern of production concentration among the top firms has prevailed in the anthracite industry for the last quarter century. Although the Glen Alden Company produced 5.8 million tons in 1950, that impressive volume still only embodied approximately twelve percent of the industry's output for that year. In the same year the top twenty firms produced 72.3 percent of all coal. The absolute production volume of the large firms deteriorated in recent years, but their relative production share has remained.

---

[1]The Pennsylvania Department of Environmental Resources cites 181 Deep, Strip and Bank operations in the 1973 Annual Report of the Office of Mines and Land Protection, and the U. S. Bureau of Mines reports eight dredge operations in the 1972 Minerals Yearbook.

TABLE II-5

MAJOR ANTHRACITE PRODUCERS

Pennsylvania Anthracite Region
1973

Operator	Production (Tons)	Cumulative % of Total Production
1. Reading Anthracite Co.	757,759	12
2. Jeddo-Highland Coal Co.	572,808	21
3. Blue Coal Corporation	459,969	28
4. Greenwood Stripping Corporation	359,741	34
5. Kocher Coal Co., Inc., Leon E.	326,266	39
6. Lehigh Valley Anthracite, Inc.	324,390	45
7. Manbeck Dredging Co., Inc.	275,800	49
8. Gilberton Coal Co.	269,920	53
9. Hecla Machinery & Equipment Co.	246,221	57
10. United Gas Improvement Corporation	244,935	61
11. B-D Mining Co.	237,411	65
12. Kerris & Helfrick, Inc.	182,688	67
13. Beltrami Enterprises, Inc.	179,767	71
14. Glen-Nan, Inc.	164,153	73
15. Schuylkill Contracting Co.	147,029	75
16. Northwest Mining Co., Inc.	97,393	77
17. Split Vein Coal Co., Inc.	66,801	78
18. Raymond Colliery Co., Inc.	64,317	79
19. Schickram, William	59,845	80
20. Rosini Coal Co.	58,752	81
Total Top 20 Companies	5,095,965	
Total Production	6,293,013	

Source: Annual Report, Pennsylvania Department of Environmental Resources, 1973, p.113.

A study by Moyer[1] in 1964 indicated that large horizontally integrated commercial companies gain financial strength through diversity of geographic markets and numerous operating units. The absence of large horizontally integrated firms in the anthracite industry today may be one of the factors which militates against the health of the industry. Although some concentration of output occurs in the anthracite industry, the absolute magnitude of these producing units pales in comparison to bituminous companies. Peabody Coal Company produced over 69 million tons of bituminous coal in 1973. The revenues and ample resources which attend such production levels enable long term contracts with large coal consumers as well as a flexible financial posture.

Moyer's studies further reveal that the large integrated companies operated 15 to 20 percent more days than the single companies in 1960. This pattern still holds for multiple-mine anthracite companies. In 1974 Pagnotti workers averaged 292 days of work compared with the industry average of 233 days.[2] For these reasons Moyer advocates consolidation as a means of strengthening the coal industry and stabilizing employment.

B.4 Characteristics of Mining Methods

Table II-6 classifies the industry's output by production method. The greatest volume of coal in each mining category is still the issue of the largest handful of firms. Twenty-five percent of the deep mining companies accounted for 78 percent of deep mine production. A few large firms exert even greater market influence when strip operations are considered. Eighty-eight percent of the production is the output of the thirteen largest companies. Culm bank recovery of coal is also dominated by thirteen large concerns.

Dredge operations have been omitted from the tabular analysis. Such operations are small in number and their little output is the least significant of all production methods. Dredge production in 1972 reached 477,000 tons, an increase from the previous year. This increase can be attributed to the erosive effects of tropical storm Agnes in 1972. In the absence of added flooding, dredge production is expected to recede by 1975.

---

[1]R. Moyer, Competition in the Midwestern Coal Industry, Harvard University Press, Cambridge, 1964.

[2]Pagnotti workers average six work days per week with two weeks vacation and eight union holidays. Pagnotti workers are strip miners and in the anthracite industry strip miners generally work more days per year than deep miners. As a result, a comparison among strip mines only would be a more accurate measure, if such figures were available.

TABLE II-6

ANTHRACITE PRODUCTION BY COMPANY SIZE
(DEEP, STRIP, CULM)

Pennsylvania Anthracite Region
1973

Company Size Tons Per Year (Thousands)	Number of Companies	Cumulative Percent Of Companies	Tons of Production	Cumulative Percent of Production
		DEEP MINE		
0-0.5	5	7	527	*
0.5-5	35	58	82,000	12
5-10	12	75	65,152	21
10-20	10	90	141,995	42
20-50	5	97	145,773	63
50+	2	100	250,508	100
TOTAL	69	100	685,855	
		STRIP MINE		
0-0.5	1	2	96	*
0.5-5	7	20	18,372	1
5-10	5	32	36,623	2
10-20	5	44	71,167	4
20-50	10	68	274,901	12
50+	13	100	2,883,766	100
TOTAL	41	100	3,284,925	
		CULM BANK		
0-0.5	3	7	794	*
0.5-5	7	23	24,039	1
5-0	1	26	5,121	1
10-20	1	28	19,367	2
20-50	18	70	547,773	27
50+	13	100	1,647,326	100
TOTAL	43	100	2,244,420	

*Less than 0.5 Percent

Source: Annual Report, Pennsylvania Department of Environmental Resources, 1973.

The present mix of production methods has evolved from a combination of forces. Just as the absolute size of production units has followed the career of the industry, the shift from deep to surface mining has been subject to the same vagaries of economic life. As production fell and technology improved, the cost advantages favored surface recovery.

Plate II-5 displays the rapid decline of deep compared to surface mining in the last six years. While the output of the industry has been almost cut in half in these last few years, deep mining's share has fallen almost five-fold. In 1973 deep mining still embraced the largest number of companies of any production method, yet accounted for only eleven percent of the annual output. A high incidence of two and three man operations is responsible for the low production rate per mine.

A longer range view of the shift from deep to surface mines is provided by Plate II-6. The loss of deep mine output is dramatic. Mine closures have hit deep mines harder than any other part of the industry. In the 1935 to 1939 pre-war period, 83 percent of production was underground. Today the overwhelming source of anthracite coal is from highly mechanized surface operations (84 percent of 1971 and 1972 production).

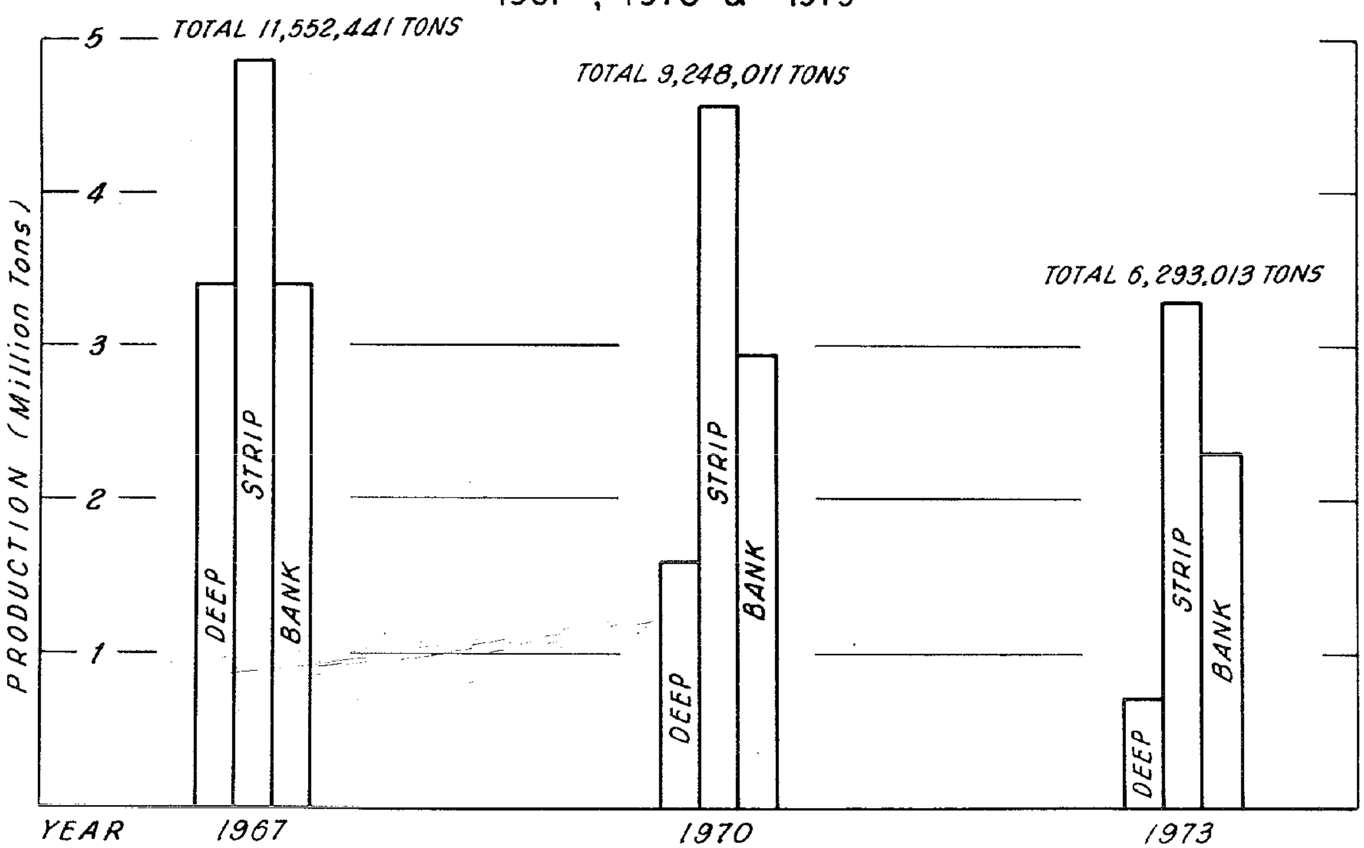
Recent figures supplied by the U. S. Bureau of Mines reveal that the capital intensive strip and bank companies boast a hefty level of labor productivity (8.37 and 31.53 tons per man day respectively) when compared to the deep mines. Once a deep mine has reached the production stage far less equipment is at the disposal of each worker. The result is an average level of deep mine labor productivity of 4.09 tons per man-day.

The ranks of underground workers have been depleted partially because of the production advantage which accrues to strip and bank employees. In the 1935 to 1939 period, 75 percent of all anthracite workers were subterranean. By 1973 their numbers had diminished so that only 18 percent of the workers were assigned to underground operations.

B.5 Characteristics of Fields

A more refined analysis of the anthracite industry is possible when each of the four producing fields is inspected separately. In Plate II-7 the 1973 production is shown, first by field, and then by method of production. The majority of anthracite in 1973 came from the Southern Field where 2.6 million tons were mined. Historically the Northern Field had been a major producer of anthracite (Table I-7) but by 1965 the Southern Field gained the lead in output. The Southern Field is where the majority of deep mining occurs due to the large volume of remaining resources and the more favorable water table conditions (see Plate II-7). Strip and culm bank recovery is also more abundant here than in any of the other Fields.

DISTRIBUTION OF ANTHRACITE PRODUCTION
BY MINING METHOD
PENNSYLVANIA ANTHRACITE REGION
1967 , 1970 & 1973



SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of the Office of Mines and Land Protection, Selected Years

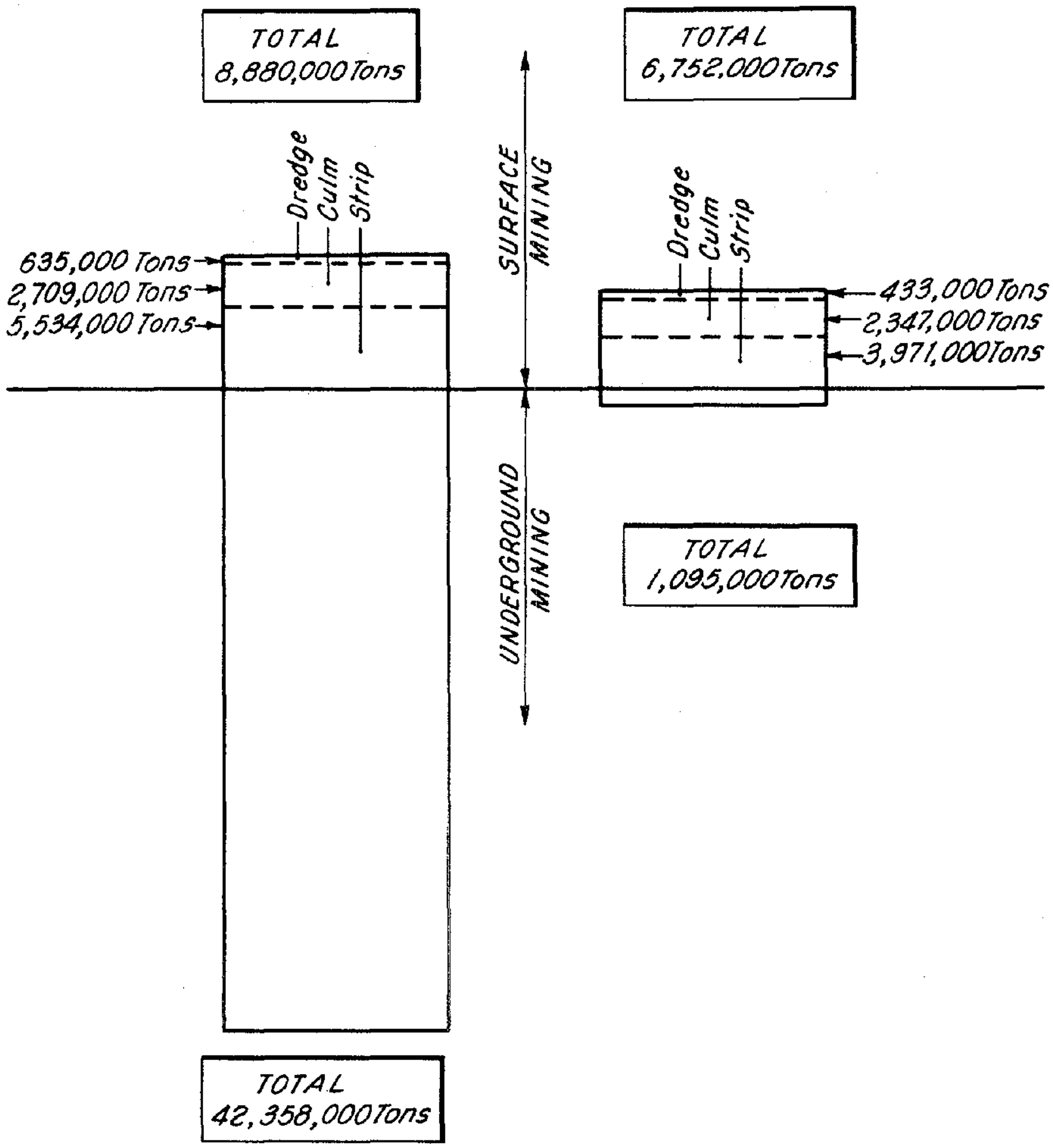
PLATE II - 5

DISTRIBUTION OF ANTHRACITE PRODUCTION

BY MINING METHOD

PENNSYLVANIA ANTHRACITE REGION

1935-1939 AVERAGE & 1971-1972 AVERAGE

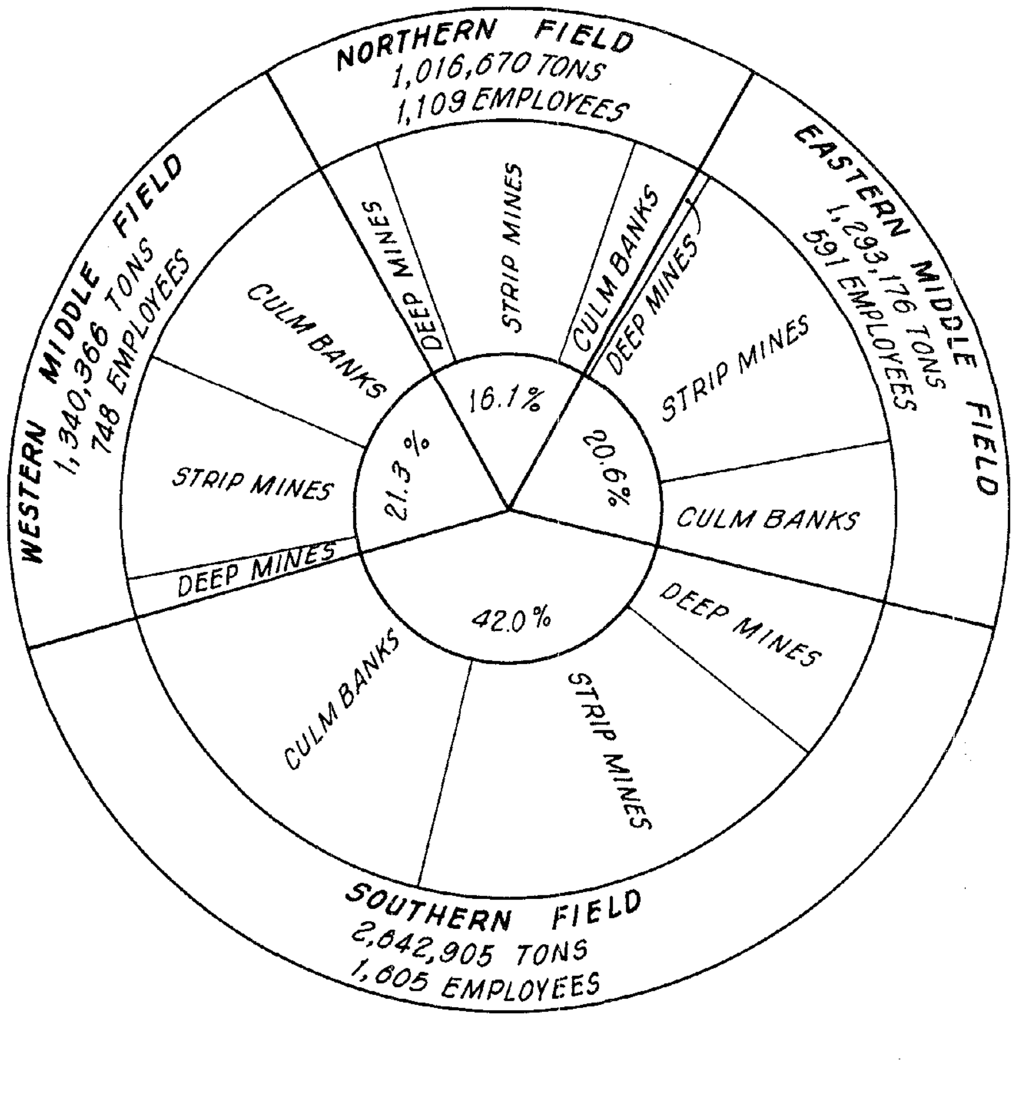


SOURCE: Prepared by Consultant based on Data from the U.S. Dept. of Interior, Bureau of Mines, Minerals Yearbook, Selected Years.

PLATE II - 6

DISTRIBUTION OF ANTHRACITE PRODUCTION

BY MINING METHOD
PENNSYLVANIA ANTHRACITE REGION
1973



SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of The Office of Mines and Land Protection, 1973.

PLATE II - 7

B.5.a The Southern Field

In the Southern Field 95 companies employ 1,047 men (Plate II-8). A pattern of mild economies of scale emerges as company size increases in all but the largest culm and deep mine companies. No assertion can be made, however, about the optimal size of a firm without a more detailed description of the individual operations.

Large firms especially dominate the strip and culm bank production in the Southern Field. Seventeen percent of the coal is deep mined here, with 43 percent derived from strip mines and 40 percent recovered from culm banks. There are also more than 40 small deep mines which each produce less than 10,000 tons annually.[1]

B.5.b The Western Middle Field

The Western Middle Field provided the second greatest tonnage of anthracite in 1973. Of the 1.3 million tons produced 49 percent was culm bank coal, and 44.3 percent was strip mined. The Western Middle Field had the smallest output of any field when strip operations are considered (Plate II-9). Surface operations in this field were dominated by nine companies who produced 87 percent of the surface coal. The productivity of the culm bank method was substantially enhanced in 1973 as the size of the producing company grew. The four largest companies recovered an average of 107 tons of coal per man day, which was over twice the industry average. Conversely, strip mining productivity fell as production by a single operation exceeded 20,000 tons per year.

The 47 separate mining companies in the Western Middle Field employed a total of 564 workers in 1973. Strip operations provided the greatest source of employment (391 workers), as well as the greatest number of man days of work (Plate II-13). One hundred and seventeen men were employed in the 24 deep mines in this field, none of which produced more than 20,000 tons of coal.

B.5.c The Eastern Middle Field

The Eastern Middle Field provided 20.6 percent of the 1973 output while employing 15.5 percent of the total work force. Stripping operations in this field produced the greatest output (67 percent) and provided the most man days of employment of any type of production (Plates II-10 and II-13). Deep mining is negligible in this field where two companies with a total of seven employees produced 4,184 tons of coal. The paucity of deep mining

---

[1] Annual Report of the Office of Mines and Land Protection, Pennsylvania Department of Environmental Resources, 1973, p.133-140.

DISTRIBUTION OF MINING COMPANIES ACCORDING TO ANNUAL PRODUCTION

SOUTHERN FIELD —— 1973

TYPE	SIZE	RECOVERY	TONS	COMPANIES	EMPLOYEES	PRODUCTIVITY TONS PER MAN-DAY
DEEP	A		422	12	27	1.4 (1)
	B		46,684	20	69	4.6
	C		67,293	10	63	3.1
	D		95,360	7	53	6.5
	E		145,773	5	91	6.4
	F		86,355	1	76	3.8
		SUBTOTAL	441,887	55	379	MEAN 5.0
STRIP	A		0	5	22	0.0 (2)
	B		10,395	4	9	8.9
	C		14,322	2	7	9.3
	D		0			0.0
	E		167,025	6	104	9.6
	F		947,096	3	351	10.9
		SUBTOTAL	1,138,838	20	493	MEAN 10.1
CULM BANK	A		0			0.0
	B		5,651	2	5	38.7
	C		5,121	1	0	0.0 (3)
	D		0		0	0.0
	E		273,760	9	38	43.2
	F		777,648	8	132	30.6
		SUBTOTAL	1,062,180	20	175	MEAN 33.1
		TOTAL	2,642,905	95	1047	

SIZE

A. <500
B. 500-5,000
C. 5,000-10,000
D. 10,000-20,000
E. 20,000-50,000
F. >50,000

NOTES: (1) Seven Deep Mines listed no Product.
(2) Backfilling
(3) Reported Stockpile.

SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of the Office of Mines and Land Protection, 1973.

PLATE II - 8

DISTRIBUTION OF MINING COMPANIES ACCORDING TO ANNUAL PRODUCTION

WESTERN MIDDLE FIELD — 1973

TYPE	SIZE	RECOVERY TONS	COMPANIES	EMPLOYEES	PRODUCTIVITY TONS PER MAN-DAY
DEEP	A	105	7	31	0.6 (1.)
	B	28,397	12	46	3.3
	C	14,745	2	14	3.9
	D	46,635	3	26	6.7
	E	0	0	0	0.0
	F	0	0	0	0.0
	SUBTOTAL	89,882	24	117	MEAN 3.6
STRIP	A	96	1	42	0.2 (2.)
	B	7,977	3	8	5.3
	C	6,327	1	3	5.9
	D	28,403	2	8	23.6
	E	49,254	2	20	9.2
	F	504,311	5	310	7.9
	SUBTOTAL	594,368	14	391	MEAN 7.2
CULM BANK	A	303	2	7	2.6
	B	2,125	1	2	14.2
	C	0	0	0	0.0
	D	0	0	0	0.0
	E	72,928	2	6	60.5
	F	580,760	4	41	107.0
	SUBTOTAL	656,116	9	56	95.1
	TOTAL	1,340,366	47	564	

SIZE

A. <500
B. 500-5,000
C. 5,000-10,000
D. 10,000-20,000
E. 20,000-50,000
F. >50,000

NOTES: (1.) Five Companies - No Production
(2.) Two Companies - Backfilling

SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of the Office of Mines and Land Protection, 1973

PLATE II - 9

77

DISTRIBUTION OF MINING COMPANIES ACCORDING TO ANNUAL PRODUCTION

EASTERN MIDDLE FIELD — 1973

TYPE	SIZE	RECOVERY TONS	COMPANIES	EMPLOYEES	PRODUCTIVITY TONS PER MAN-DAY
DEEP	A	0	2	4	0.0 (1)
	B	4,184	2	7	3.4
	C	0	0	0	0.0
	D	0	0	0	0.0
	E	0	0	0	0.0
	F	0	0	0	0.0
	SUBTOTAL	4,184	4	11	
STRIP	A	0	2	17	0.0 (2)
	B	0	0	0	0.0
	C	0	0	0	0.0
	D	27,553	2	19	5.8
	E	26,466	1	25	3.6
	F	810,680	3	253	9.7
	SUBTOTAL	864,699	8	314	
CULM BANK	A	491	1	6	54.6
	B	4,800	1	4	24.5
	C	0	0	0	0.0
	D	0	0	0	0.0
	E	69,153	2	9	38.5
	F	349,849	2	26	83.7
	SUBTOTAL	424,293	6	45	49.8
	TOTAL	1,293,176	18	370	

SIZE

A. <500
B. 500-5,000
C. 5,000-10,000
D. 10,000-20,000
E. 20,000-50,000
F. >50,000

NOTES: (1.) No Production
(2.) Backfilling

SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of the Office of Mines and Land Protection, 1973.

PLATE II - 10

can be attributed to the relatively scarce amount of resources and the historically thorough depletion of the shallow, mildy pitched veins. Culm bank coal is produced primarily by two companies (82 percent of production in 1973).

No stripping companies of less than 10,000 tons per year operated in the Eastern Middle Field in 1973. Two companies were engaged in backfilling operations, employing a total of 17 workers in this capacity. Of the 18 individual mining companies in the Eastern Middle Field, five firms with surface operations accounted for 90 percent of the Field's total output.

B.5.d <u>The Northern Field</u>

The Northern Field yielded the smallest output of all Fields, with some 751 employees retrieving a million tons of coal (Plate II-11). Deep mines and culm operations each contributed 16 percent of the total output. Culm bank recovery in the Northern Field is by far the lowest of all the Fields. This is perhaps opposite of what might be suspected considering the large amount of raw coal extracted from the Northern Field historically.[1]

The usual economies of scale pattern does not occur in the Northern Field in culm or strip operations. One successful medium sized culm company in this Field (Sullivan Trail Coal Company) tallied an unusually high rate of 89.3 tons per man day for 31 days of operation. Similarly, in the strip operations, the middle sized Bliss Brothers Coal Company produced 25.1 tons per man day, more than twice the industry average for 1973. The productivity among the one medium size and three large Northern Field strip operations was unusually low, however.

The third largest producer of anthracite coal in 1973, the Blue Coal Company, ceased operations in May of 1974. Since this company operated exclusively in the Northern Field, the result may be a further decline of northern production.

B.6 <u>Labor Productivity</u>

To inspect some of the patterns of labor productivity that have emerged from the analysis of individual Fields, Plate II-12 has been constructed. The 1973 deep, strip and culm labor productivity rates have been synthesized for all Fields. The operations are divided into three categories (i) those

---

[1]Explanations for the relatively curtailed culm bank operations in the Northern Field are as follows: (a) culm material has been used as deep mine fill under cities in the Northern field; (b) the higher quality culm banks have already been depleted; (c) fires have reduced the number of recoverable banks.

DISTRIBUTION OF MINING COMPANIES ACCORDING TO ANNUAL PRODUCTION

NORTHERN FIELD —— 1973

TYPE	SIZE	RECOVERY TONS	COM-PANIES	EMP-LOYEES	PRODUCTIVITY TONS PER MAN-DAY
DEEP	A	0	0	0	0.0
	B	2,735	1	4	2.7
	C	0	0	0	0.0
	D	0	0	0	0.0
	E	0	0	0	0.0
	F	164,153	1	222	3.1
	SUBTOTAL	166,888	2	226	MEAN 3.0
STRIP	A	0	16	6	0.0
	B	0	0	0	0.0
	C	15,974	2	8	9.0
	D	17,211	1	81	3.8
	E	32,156	1	5	25.1
	F	621,679	36	374	5.5
	SUBTOTAL	687,020	56	474	MEAN 5.6
CULM BANK	A	0	0	0	0.0
	B	11,463	3	10	14.5
	C	0	0	0	0.0
	D	19,367	1	7	89.3
	E	131,932	5	34	40.0
	F	0	0	0	0.0
	SUBTOTAL	162,762	9	51	MEAN 34.8
	TOTAL	1,016,670	67	751	

SIZE

A. < 500
B. 500 - 5,000
C. 5,000 - 10,000
D. 10,000 - 20,000
E. 20,000 - 50,000
F. > 50,000

SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, *Annual Report of the Office of Mines and Land Protection*, 1973

PLATE II - 11

LABOR PRODUCTIVITY OF ANTHRACITE MINES
(SMALL, MEDIUM & LARGE MINES)
PENNSYLVANIA ANTHRACITE REGION
1973

SOURCE: Prepared by Consultant based on Data from the Pa. Department of Environmental Resources, Annual Report of the Office of Mines and Land Protection, 1973

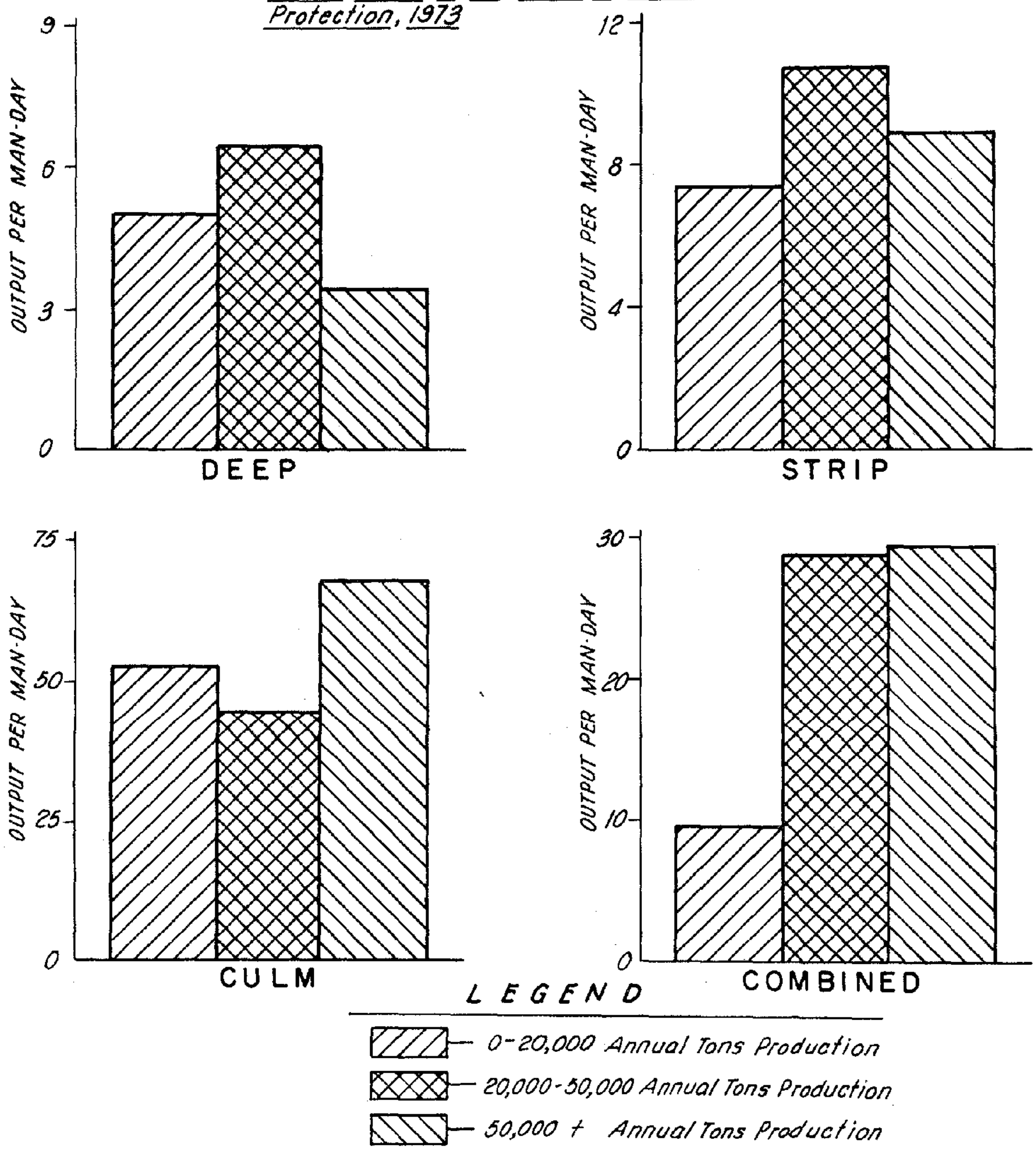


PLATE II - 12

producing less than 20,000 tons per year, (ii) those producing between 20,000 and 50,000 tons per year, and (iii) those producing more than 50,000 tons per year. Medium sized firms appeared to be most productive among strip and deep mine operations in 1973 (10.8 and 6.4 tons per man day, respectively), while the larger size operations made best use of their labor in silt recovery (67.4 tons per man day). This type of analysis has severe limitations, however, since inputs such as capital have been ignored and labor alone is the touchstone.

C. LABOR

C.1 Work Force

The U. S. Bureau of Mines has listed the labor force in the anthracite industry at 4,783 in 1972. The workers were involved in all facets of the extraction and preparation process in thirteen counties of Pennsylvania. Although the Pennsylvania Department of Environmental Resources provides a breakdown of the work force by counties, dredge workers are excluded.

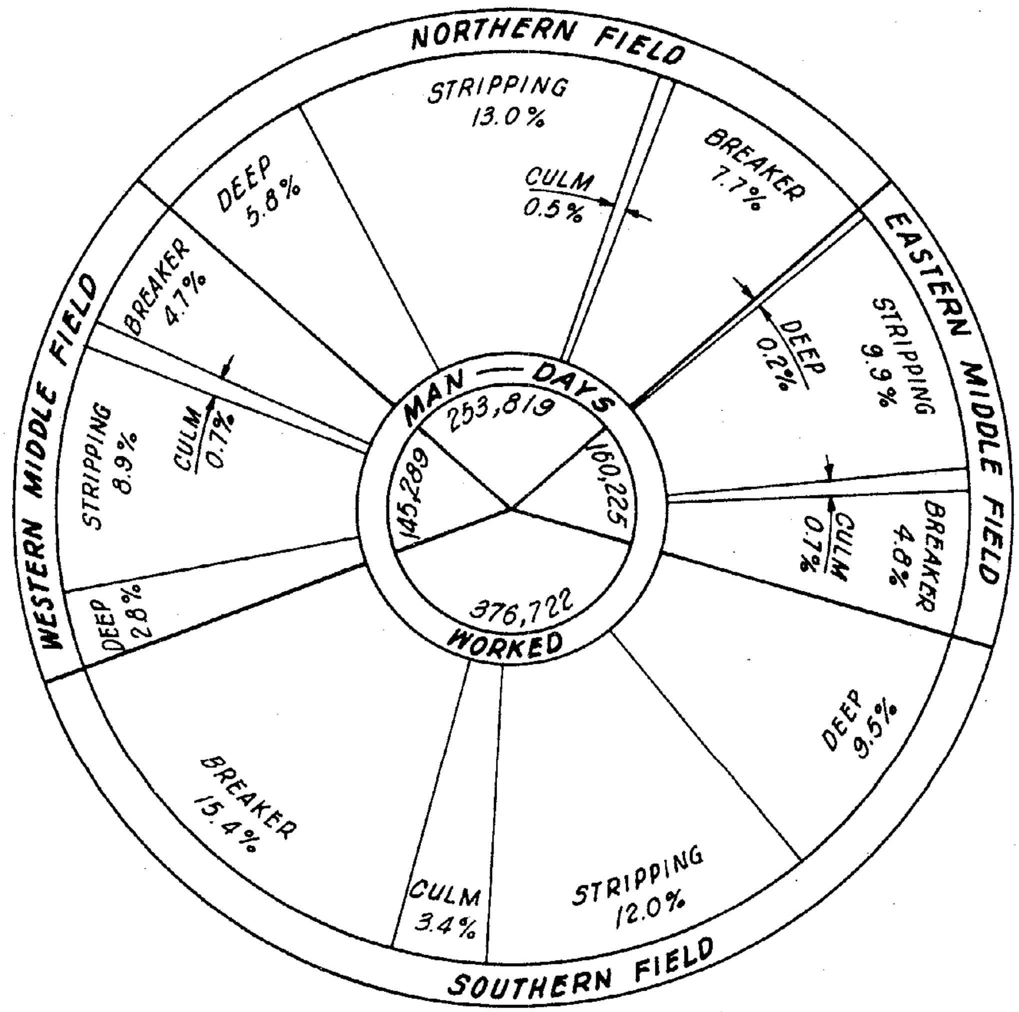
According to Table I-8 the bulk of anthracite miners worked in Luzerne and Schuylkill Counties in 1973 (79 percent). The 3,200 anthracite workers in these two counties, however, represented less than two percent of their total civilian labor force in 1973.

The distribution of 1973 man days of work in the anthracite industry is represented in Plate II-13. The Southern Field received 377,000 of the industry's total 936,000 man days invested in 1973. In this field breaker operations consumed a greater number of man days than any single extraction process. In all the Fields, 44 percent of the 1973 man days were spent in strip operations, compared to 33 percent of the man days employed in cleaning and preparing coal.

When the employees are considered by type of work it is apparent that the majority are involved in surface operations (82 percent in 1973). This is not surprising when the production figures by operation are considered. The 3,317 surface workers not only extracted 89 percent of the coal in 1973, but also cleaned and prepared all of the coal for market.

In 1950, the 48,000 deep miners represented 67 percent of the industry's employees. The flight of workers from the deep mines has paralleled the falling deep mine production (see Table II-7). Since the majority of anthracite reserves are below 500 feet, this trend may eventually have to be reversed if the industry is to thrive. In the words of Paul Smith, Secretary of the Pennsylvania Department of Labor and Industry:

DISTRIBUTION OF MAN DAYS
BY MINING METHOD
PENNSYLVANIA ANTHRACITE REGION
1973



SOURCE: Prepared by Consultant based on Data from the Pa. Dept. of Environmental Resources, Annual Report of The Office of Mines and Land Protection, 1973.

PLATE II - 13

TABLE II-7

TOTAL ANTHRACITE EMPLOYMENT BY TYPE

Selected Years 1950-1972

Type	1950	1955	1960	1965	1970	1971	1972
Miners-Laborers	31,314	13,175	-	-	-	-	-
Other Underground	17,112	6,677	9,041*	4,501	1,423	1,440	650
Strip	7,949	4,642	3,470	2,349	1,809	1,800	2,011
Culm	-	-	585	566	494	540	314
Dredge	-	-	128	97	62	60	50
Preparation	4,842	3,844	3,145	2,047	1,655	1,500	1,471
Other (Surface)	11,407	5,085	2,682	1,572	566	460	287
Total	72,624	33,523	19,051	11,132	6,000	5,800	4,783
Man Days of Labor	15,349,800	6,610,143	3,360,455	2,271,202	1,447,000	1,384,000	1,033,000

*After 1960 all underground workers are grouped together

Source: Minerals Yearbook, United States Department of the Interior, Bureau of Mines, Selected Years

To reverse this trend and revive anthracite deep mining, a number of barriers must be overcome. The one with which the subcommittee (Manpower) is most concerned is the lack of interest on the part of potential workers to get into this kind of occupation. It is simply not very appealing work, but we believe this can be corrected to some extent if it is clear that deep mining is a safe occupation; that it pays well; that there are opportunities for advancement; and that it is not a degrading occupation.[1]

Any significant increase in anthracite production, be it by strip or deep mining method, will require a lead time to develop new mines. Surface mines require two to three years preparation and for deep mines a four to six year development stage can be expected.[2] At the same time, any attempt to raise production will require trained workers. Current training periods range from one to three years for miners, to four academic years for mining engineers.[3] Since the outlook for a prospective worker is quite bleak, training programs to this point have been minimal.

C.2 Manpower Programs

Pennsylvania has promoted several training programs for the mining industry since the inception of the Manpower Development Training Act (MDTA) in 1962. An average of 60 mine machinery mechanics were trained annually under MDTA in a 52 week institutional program.[4] This program, as well as on the job training run by the AFL-CIO Appalachian Council, through an MDTA contract, were both concerned with the bituminous coal industry, however.

A special training program was set up by the Pennsylvania Department of Labor and Industry in July, 1974, based on projected manpower needs. The program was funded by state and federal monies to the benefit of both the anthracite and bituminous industries. On the basis of a 1974 needs

---

[1]Paul Smith, Secretary of the Pennsylvania Department of Labor and Industry, Working Papers for the "Coal For The 70's Pennsylvania Action Conference", April 24, 1974.

[2]Rogers C. B. Morton, U. S. Secretary of the Interior, "News Release", March 29, 1974.

[3]Harry Perry, excerpts from the Cornell Workshops on the "National Energy Research and Development Program", 1974, p.84.

[4]"Governor Milton J. Shapp Master Plan, Training Program for Pennsylvania Coal Industry, Bituminous and Anthracite", 1974, p.2.

survey conducted by the United Mine Workers of America and the Independent Miners and Associates, the following projections for the anthracite industry were made:

> The intermediate training of 60 equipment operators for strip mine operations; 75 heavy truck, dump, for both strip and deep mines; 45 blaster-drillers for both deep and strip mines; 120 miners for deep and strip mines; 25 mine electricians for deep and strip mines. . . .[1]

Courses became available in July for equipment operators, blaster-drillers, heavy truck drivers, mine electricians, Miner I trainees and mine safety. The courses ranged from five to 24 weeks in duration, with a total of 325 available trainee slots. Potentially, the most important offering in the anthracite industry was the Miner I course. The six weeks of pre-employment orientation stressed safety and deep mining. After the second six week session the program was cancelled due to inadequate enrollment. The remaining courses have met with limited success in completion and placement records, but the entire MDTA program for miners was phased out in December, 1974, since no federal funds were available for any MDTA statewide programs in fiscal year 1975.

The Federal Community Employment Training Act (CETA) has replaced the MDTA training program. CETA has not provided for the continuation of mine training programs without the initiation of individual program areas. No such requests from communities have been forthcoming as of December, 1974.

At the county level, The Schuylkill County Economic Opportunity Cabinet has initiated a course to train 30 individuals for deep mine careers. The "Team" project is coordinated by the Pennsylvania Department of Community Affairs and sponsored by the federal, state and local governments. The program is scheduled to begin in February of 1975 and terminate after 130 days of training. The 30 days of classroom training is comparable to the defunct MDTA Miner I course. A special feature of this program is 100 days of on the job training. Recruitment is geared to attract local residents who are unemployed or underemployed.[2]

---

[1]Governor Milton J. Shapp Master Plan, Training Program for Pennsylvania Coal Industry, Bituminous and Anthracite, 1974, p.6, 7.

[2]Economic Opportunity Cabinet of Schuylkill County, "Team" project proposal, submitted to the Pennsylvania Department of Community Affairs, October 31, 1974.

Vocational technical training programs at the secondary high school level do not offer mining courses in the Anthracite Region. Training programs for supportive skills are available, however. As a single example the Wilkes-Barre Vocational Technical School has been operating since 1972. Courses ancillary to mining include: heavy equipment operation, heavy equipment (diesel) operation, welding, electricity and carpentry. The Vo-Tech Cooperative Student Program at Wilkes-Barre has made no placements in the mining industry as of January, 1975.[1]

The College of Earth and Mineral Sciences of The Pennsylvania State University contributes to the overall supply of trained miners. Some of the MDTA programs have been operated at Penn State facilities. The list of active mine related continuing education and training projects provided by the University in 1973 includes eleven non-degree programs. Of interest to the anthracite industry are the special health and safety seminars for authorized representatives of miners: The Smith-Hughes course (to help prepare miners and supervisors for the Foreman's Certification examination); The short course (Technical and Nontechnical Courses for Engineers, Safesmen, Supervisors and Others), and Integrated Surface Mining Techniques (a pilot course presented in Western Maryland in July, 1973). The location of these offerings is not necessarily convenient to those who live in the Anthracite Region, however.

At the university level it has been estimated that 120 mining engineers were graduated nationally in 1973.[2] Only 20 colleges and universities in the U.S. offered undergraduate degrees in mining engineering or related fields. If the anthracite industry were faced with an increased need for mining engineers they would have to compete with other mining occupations for the limited number of qualified graduates. However, a possibility exists of recruiting additional mining engineers from other engineering fields.

Although the United Mine Workers of America do not make a direct investment in the training of human capital, the current labor contract provides for a Joint Anthracite Advisory Training Committee. The purpose is to promote manpower training in the industry.[3]

---

[1]Robert Jones, Director of Wilkes-Barre Area Vocational Technical School, from a telephone communication, January, 1975.

[2]"Trained Skilled Mining Techniques, Problems and Suggestions", Educational Projects, Inc., Prepared for the Pennsylvania Department of Commerce, April 26, 1974.

[3]"United Mine Workers of America, District 25, Anthracite Wage Agreement of April 16, 1972", p.5.

The manpower training programs to date are a reflection of the lethargic anthracite industry. Conversations with local manpower officials repeatedly revealed two major constraints. First - monies and effort cannot be expended to train workers for jobs that simply are not available. Second - the image of the mine industry is quite low in the anthracite area and must be enhanced to stimulate interest and increment the labor force.

C.3 Unions

More than half of the present work force in the Anthracite Region is unionized under the United Mine Workers of America (UMWA). The majority of the remaining workers are independents and members of the Independent Miners and Associates (IMA), or Independent Miners, Breakers and Truckers Association (IMBTA).

C.3.a The United Mine Workers of America

The United Mine Workers Union represented 2,500 of the 4,400 active anthracite workers in 1974.[1] The total membership in the Anthracite Region in 1974 reached 15,000 in number. The majority of members are retired pensioners who have an option to join the Union for a fee of $1.25 per month. The active anthracite workers, on the other hand, pay a monthly membership fee of $9.00.

In 1963, the average age of unionized anthracite workers was 47 years.[2] An estimate of the average age in 1974 is put at 45 years.[3] Both figures exceed the national average for operatives, which was 39.2 in 1960, and 38.9 in 1970. The average age for all employees was also below the average miners age. The implication is that the arduous work required of expert miners is the burden of an older, less physically capable group. The industry has failed to attract sufficient new younger men to lower the average age.

The Anthracite Health and Welfare Fund is financed through a contribution by operators based on tons of production. In 1974, payments to the Fund were 90 cents per ton. The union pension for retired anthracite workers pays a benefit of $30 per month for survivors. There are 14,190 pensioners today, and this figure has somewhat stabilized after an expansion in 1971, when eligibility requirements were eased. According to William Savitski, Chairman

---

[1]From an Interview with UMWA, District 25, Officials, December 4, 1974.

[2]G. Schenck and J. Schantz, Jr., The Economic Importance of the Coal Industry to Pennsylvania, The Pennsylvania State University, submitted to The Pennsylvania Coal Research Board, SR-64, 1967, p.78.

[3]From an Interview with UMWA, District 25, Officials, December 4, 1974.

of the Anthracite Health and Welfare Fund, even with the current meagre benefits, the Fund is financially unsound and has "no choice except to seek government assistance as receipts available are inadequate."[1] The Fund has applied for assistance under the 1974 Pension Reform Act.

C.3.b The Independents

The independent organizations are roughly divided into two geographic areas of jurisdiction - the IMBTA organizes mines in the Northumberland and Columbia Counties. The bailiwick of the IMA is Schuylkill, Dauphin, and Columbia Counties. There is some overlapping on the boundaries of each organization's power. The function of the independent organizations more resembles a coal operator's association than a labor union. There are no contracts negotiated or pension funds provided to the workers. The independents' primary function is to safeguard the anthracite industry employers and workers alike, through inputs into regulatory and legislative decisions. Both organizations are based financially on a tonnage contribution scheme which is shared by the operators and the breakers. The lobbying function of the two Associations has been curtailed due to financial constraints.

In 1974 the IMA represented 725 workers from 44 active anthracite operations, while the IMBTA membership included 80 active operations and 614 men. The majority of operations participating in the IMA or IMBTA are breakers and washeries. The independent deep mines, however, represent most of the deep mines active in 1974.

C.4 Wages

Members of the UMWA work under separate contracts in the Anthracite and Bituminous Regions. The current anthracite wage agreement was adopted on April 16, 1972. The contract expires on March 31, 1975.[2] The wage outlined in this agreement varies substantially from the bituminous wage agreement for a comparable period, which terminated on November 12, 1974. The anthracite agreement proclaims wages for a seven hour day ranging from $3.84 per hour to $4.59 per hour for various workers in strip operation. At the same time strip and auger miners in the bituminous industry commanded compensation rates of from $5.69 per hour to $6.90 per hour. Similar discrepancies prevail in the deep mining wage structure.

Since greater than one third of all anthracite workers are non-union, wages are not standardized. Wages for non-union workers in the anthracite industry often exceed that of their unionized counterparts, but industry

---

[1] "The Patriot" Patriot-News Company, Harrisburg, Penna., October 24, 1974.

[2] UMWA Wage Agreement, op. cit.

wages are by no means uniform. The trainees placed under the MDTA Miner I course found that starting wages range from $23 to $40 per day.[1]

Table II-8 provides historical data on the wages in selected industries. From a comparison of columns 1 and 2 it is apparent that the anthracite-bituminous differential has grown historically. In 1954, both anthracite and bituminous workers received $2.40 per hour. By 1972, the average bituminous coal miner earned $5.34, as opposed to the $3.71 per hour figure in the anthracite industry.

Plate II-14 and the remaining columns of Table II-8 indicate that wage hikes have been milder in the anthracite industry than in all of the major occupational fields listed in the last 19 years; wages in all occupational categories more than doubled while anthracite wages increased by a factor of 1.5 only. From Plate II-14 anthracite wages can be seen to have fallen below those in the petroleum and natural gas industries by 1965. In 1972, manufacturing trades paid wages in excess of those paid to anthracite workers.

An analysis of absolute wage rates must, however, be tempered by a consideration of the cost of living per region, as well as the wage structure for alternative occupations within the region. Table II-9 presents a picture of earnings in the anthracite area for various occupational groups. Anthracite workers, when compared to local groups, fare quite well. Approximately, 38 percent of the labor force in the anthracite area is engaged in manufacturing,[2] in which the average weekly earnings was $115.61, well below the average earnings in the anthracite industry of $147.29 per week in 1972.

Anthracite workers have consistently taken home larger pay checks than local textile workers and food and kindred product workers. The fabricated metal workers have been receiving similar average weekly pay checks in the 1955 - 1972 period, while printing and publishing employees have consistently earned more than anthracite workers.

The fact that the anthracite industry is located in a relatively low wage area of Pennsylvania (Table I-4) does not fully explain the deviation between anthracite and bituminous workers' pay checks. The result is a cost advantage in labor which accrues to the anthracite industry.

---

[1]Progress Report, Pennsylvania Department of Labor and Industry on MDTA training at N. Schuylkill County AVTS - Miner I program, October 25, 1974, p.2.

[2]General Social and Economic Characteristics of the Population, 1970, U. S. Census Bureau, Vol.40, p.673, 675-7.

TABLE II-8

AVERAGE HOURLY EARNINGS IN ANTHRACITE AND SELECTED INDUSTRIES

United States
1954-1972

Year	Anthracite Mining	Bituminous Coal Mining	Metal Mining	Petroleum & Natural Gas Production	All Manufacturing	Chemical	Motor Vehicles and Equipment	Textile Mills
1954	$ 2.40	$ 2.40	$ 2.04	$ 2.15	$ 1.78	$ 1.89	$ 2.20	$ 1.36
1955	2.35	2.47	2.16	2.20	1.86	1.97	2.29	1.38
1956	2.40	2.72	2.27	2.35	1.95	2.09	2.35	1.44
1957	2.63	2.92	2.39	2.47	2.05	2.20	2.46	1.49
1958	2.63	2.93	2.46	2.54	2.11	2.29	2.55	1.49
1959	2.75	3.11	2.55	2.65	2.19	2.40	2.71	1.56
1960	2.75	3.14	2.66	2.69	2.26	2.50	2.81	1.61
1961	2.73	3.12	2.74	2.80	2.32	2.58	2.86	1.63
1962	2.74	3.12*	2.83	2.83	2.39	2.65	2.99	1.68
1963	2.78	3.15*	2.88	2.92	2.46	2.72	3.10	1.71
1964	2.83	3.30*	2.96	2.95	2.53	2.80	3.21	1.79
1965	2.94	3.49*	3.06	3.03	2.61	2.89	3.34	1.87
1966	3.04	3.66*	3.17	3.13	2.72	2.99	3.44	1.96
1967	3.10	3.75*	3.24	3.25	2.83	3.10	3.55	2.06
1968	3.21	3.86*	3.42	3.39	3.01	3.26	3.90	2.21
1969	3.32	4.24*	3.64	3.60	3.19	3.47	4.10	2.34
1970	3.40	4.58*	3.88	3.83	3.36	3.69	4.22	2.45
1971	3.48	4.86	4.12	4.15	3.56	3.94	4.72	2.57
1972	3.71	5.34*	4.47	4.46	3.81	4.20	5.11	2.73

*Eleven-Month Average

Source: U. S. Bureau of Labor Statistics

AVERAGE HOURLY EARNINGS FOR SELECTED INDUSTRIES

UNITED STATES

1955-1972 (SELECTED YEARS)

SOURCE: *National Coal Association, Bituminous Coal Data, 1973; U.S. Dept. of Labor, Bureau of Labor Statistics, Employment and Earnings, States and Areas, 1939-1972.*

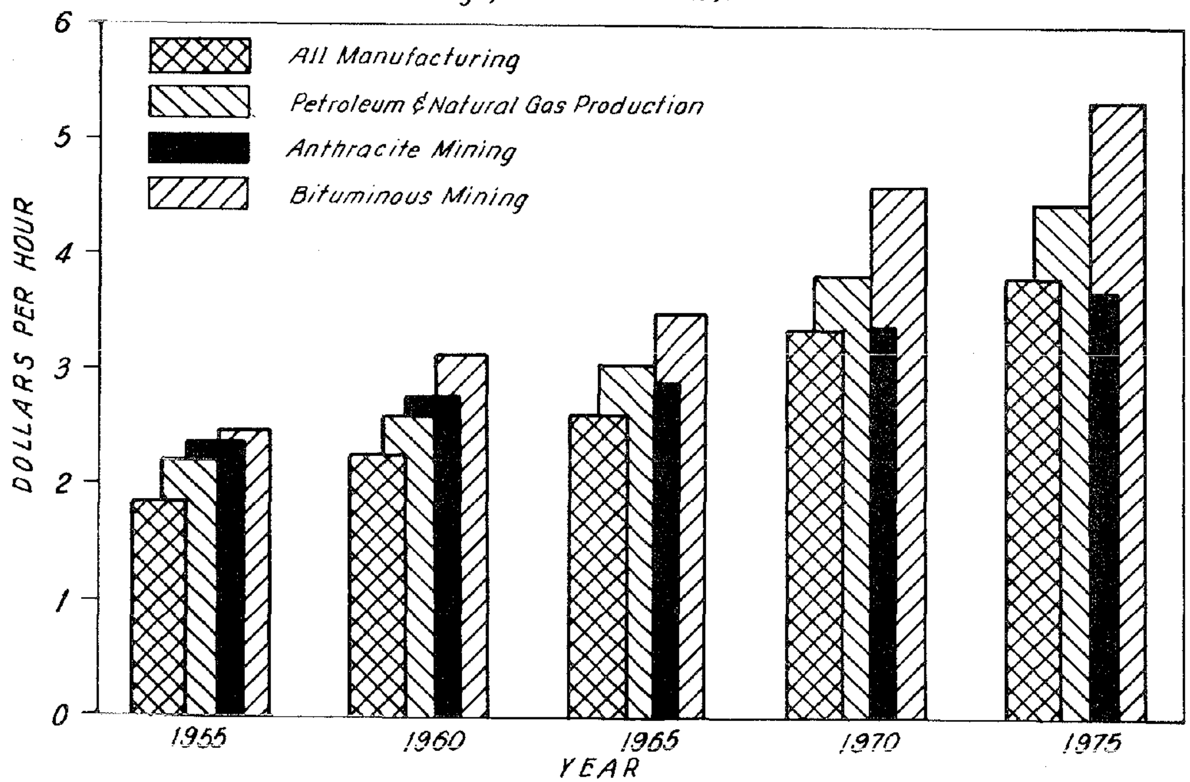


TABLE II-9

COMPARATIVE WEEKLY EARNINGS

Pennsylvania Anthracite Area[1]
Selected Years 1955-1972

Year	Anthracite Mining	All Manufacturing	Textiles[2]	Fabricated Metals	Food and Kindred Products	Printing & Publishing
1955	$ 78.73	$ 53.59	$ 53.23	$ 73.52[3]	$ 67.69[4]	$ N/A
1960	88.83	63.73	60.99	95.55	75.81	N/A
1965	100.50	74.96	58.97	104.99	91.14	117.26[5]
1970	133.91	99.65	78.90	128.54	111.63	145.71
1971	138.50	107.16	85.30	134.08	122.63	156.22
1972	147.29	115.61	95.63	148.11	130.10	167.21

[1]Wages from anthracite mining represent wages for the entire 10 county area. Wages for manufacturing, textiles, fabricated metals, food and kindred products and printing and publishing are taken from Lackawanna and Luzerne Counties.

[2]1955 and 1960 data is for textile mill products only. Apparel and other textile products have been excluded.

[3]Lackawanna County only.

[4]Luzerne County only.

[5]Lackawanna County only.

Source: Employment and Earnings, States and Areas 1939-72, U. S. Department of Labor, Bureau of Labor Statistics.

D. INDUSTRY COSTS

D.1 General

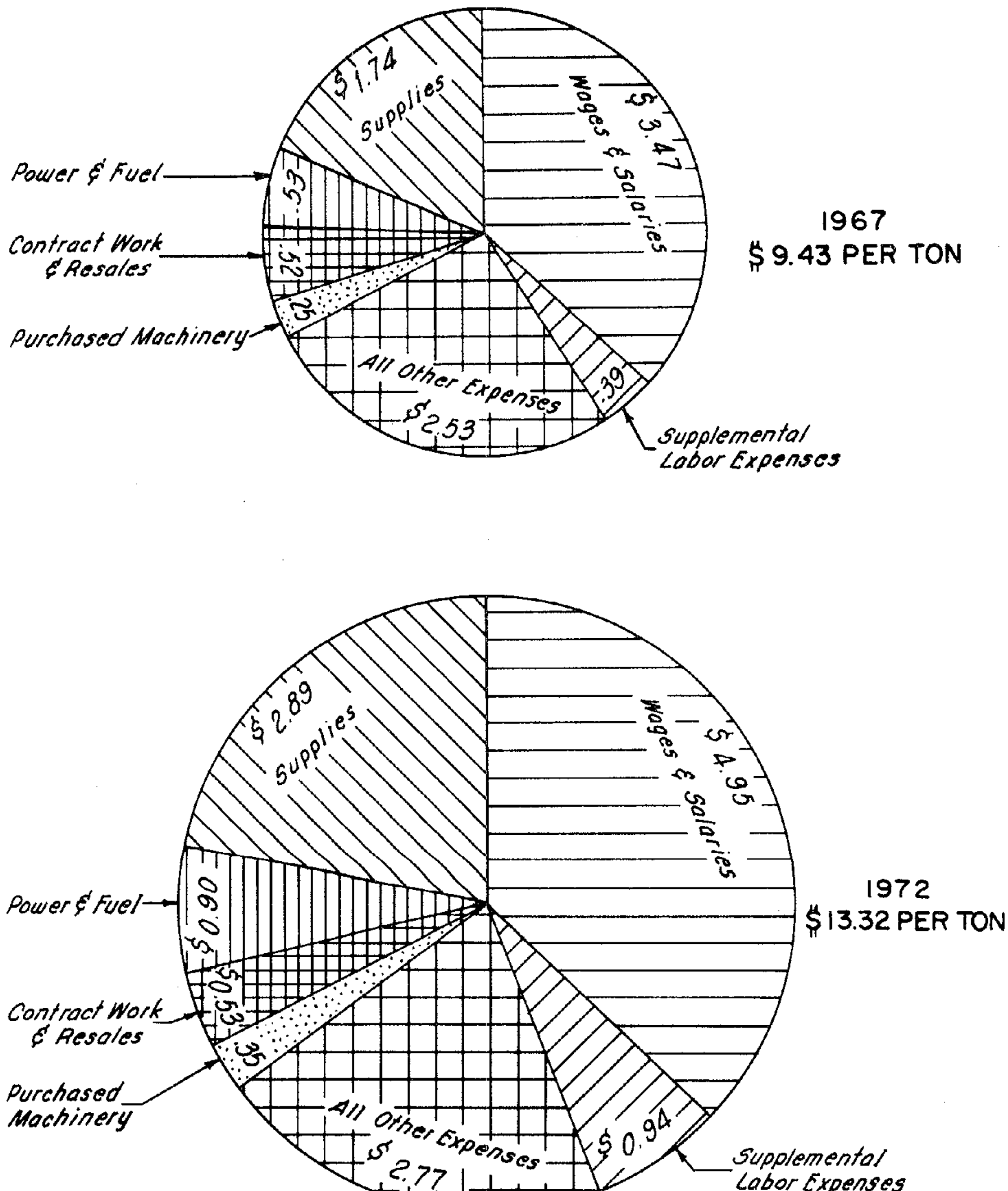
The wages earned by anthracite workers are but a single component of the total production cost schedule which faces the coal operator today. To justify his effort a mining entrepreneur must establish an extraction process whereby wages, rents, interest and preferably a profit are recouped when the coal is sold. As the producer attempts to combine labor and capital in an optimal fashion, he must also locate where nature will most favorably yield to mining. In the extraction process the quality and pitch of the coal measures to be retrieved, the amount of water which must be pumped, and the amount of overburden attending the veins of the surface mine are important cost considerations which will vary from location to location. The wealth of variables involved in any mining process discourages attempts to construct a "typical" mine cost schedule, short of the market price. The price which coal is selling for must, in the long run, cover all operating costs, to rationalize the allocation of resources to a mining enterprise.

D.2 Total Cost

The average value of net shipments and receipts of anthracite coal, reported by the U. S. Bureau of Census, is the total of all costs incurred in the extraction and preparation process. This figure is an industry average of the combined costs of deep, strip and culm mines, as well as preparation plants. The 1972 average value of net sales and receipts, hence costs for producing a ton of anthracite coal, came to $13.32 per ton. This figure is somewhat greater than the total bituminous cost of $7.94 per ton. The cost advantage of winning bituminous coal results from a variety of cost factors. Bituminous coal is, by nature, more accessible than anthracite. The veins are of a flatter pitch, there is less dewatering required, and the overburden is softer. A dearth of technological innovation and large scale operations also works against anthracite operators and raises their relative costs.

The total cost of anthracite coal mining is disaggregated into seven cost categories in Plate II-15. The lion's share of the production costs is in the wages, salaries and supplemental labor costs reported on Plate II-15, and Table II-10. In 1972, anthracite producers paid an average of $4.95 per ton of coal in wages and salaries. The 1967 figure of $3.47 per ton cannot be meaningfully compared, however, since the two figures are not calculated in constant dollars. However, an analysis of the relative input shares still remains valid. The mix of variable inputs has changed in the five year period and the labor bill represents a smaller component of costs while the relative outlay for supplies (broadly defined) appreciated. The shift in the production methods from underground to the surface exerted an influence on the labor/capital mix as well as the relative cost share of labor and supplies.

AVERAGE ANTHRACITE PRODUCTION COSTS PER TON
PENNSYLVANIA ANTHRACITE REGION
1967 AND 1972



SOURCE: Prepared by Consultant based on Data from the U.S. Bureau of Census "Census of Mineral Industries", 1972

PLATE II - 15

TABLE II-10

AVERAGE ANTHRACITE MINING COSTS

Pennsylvania Anthracite Industry
1967 and 1972

	1972		1967	
	Cost (Millions of Dollars)	Cost Per Ton (Dollars)	Cost (Millions of Dollars)	Cost Per Ton (Dollars)
Labor	42.0	5.89	45.7	3.86
Wages and Salaries	35.3	4.95	41.1	3.47
Supplemental Labor Expenses	6.7	.94	4.6	.39
Supplies, Machinery, Etc.	33.3	4.67	36.0	3.04
Supplies	20.6	2.89	20.6	1.74
Power/Fuel	6.4	0.90	6.3	0.53
Contract Work & Resales	3.8	0.53	6.1	0.52
Purchased Machinery	2.5	0.35	3.0	0.25
All Other Expenses	19.7	2.77	30.0	2.53
Net Shipments and Receipts	95.0	13.32	111.7	9.43

Source: Prepared by Consultant based on data from:

"Anthracite Mining", Census of Mineral Industries, U. S. Bureau of Census, 1972.

Table II-11 highlights the relative deep and strip mine production costs. A comparison of disaggregated 1967 cost components indicates that payrolls commanded a larger share of deep mining costs, as would be expected for a labor intensive production process. The supplies category is distorted, however, by the inclusion of purchased coal. The cost of coal received for preparation by operators which have such facilities is included in the supplies category. The total value of shipments of deep mines exceeded that of strip mines in 1967, although production was greater among strip mines. Again the distortion may be due to coal resales to preparation plants.

TABLE II-11

ANTHRACITE STRIP AND DEEP MINE COSTS COMPARED

Pennsylvania Anthracite Industry
1967

	STRIP		DEEP	
	Cost (Millions)	Percent of Total Cost	Cost (Millions)	Percent of Total Cost
Payroll	9.3	25.2	15.9	39.2
Supplies[1]	10.6	28.7	10.4	25.6
Fuel Purchased	0.7	1.9	0.4	0.9
Power Purchased	1.1	3.0	1.1	2.7
Contract Work	2.8	7.6	1.2	3.0
Undistributed	12.4	33.6	11.6	28.6
Total Value of Shipments	36.9	100.0	40.6	100.0

[1]Includes minerals received for preparation, and purchased machinery installed.

Source: Prepared by Consultant based on data from:

"Anthracite Mining", Census of Mineral Industries, U. S. Bureau of Census, 1969.

D.3 Special Costs

Some special costs in producing anthracite, associated with particular mining approaches, are worthy of individual attention. The first, dewatering, is a cost encountered in both deep and strip mining. Extraction costs are inflated by the expense of pumping and treating acid mine water.

A sample of the treatment costs for mine water is available from the Anthracite Research and Development Company. The Rausch Creek Mine Drainage Treatment Plant cost $1.75 million for construction, and $0.3 million for engineering and design costs in 1973. This is a large scale facility designed to treat ten million gallons of water per day. During the design phase there were 28 active mine operations, six abandoned workings, and an overflow from a mine pool which contributed to the drainage pollution in the stream. No figures are available on daily operating costs.[1]

The costs associated with pumping water from the workings depends on the volume of water and the head which the water must be pumped against. The volume of water which must be pumped varies greatly from mine to mine, but from a sample of three deep mines in operation today, 61.2 tons of water were being pumped per ton of coal produced. As pumping volumes become excessive, deep mines are forced to close. Although strip operators also incur dewatering expenses it is generally a less decisive factor in the economics of the operation. A more detailed analysis of dewatering is presented in Chapter IV.

The overburden ratio encountered in the strip operation is another cost factor which comes into play. This ratio refers, by one generally accepted definition, as the cubic yards of overburden which must be dug to recover a ton of coal. When this figure is excessive, stripping coal is constrained by the cost of excavating and the cost of reclamation once the coal is removed. Reclamation costs for anthracite strip mines generally exceed those of bituminous mines because of the deeper excavations. The Pennsylvania Surface Mining Conservation and Reclamation Act of 1971 requires a strip operator to post a bond which generally ranges from $500 to $1,000 per acre in case of default in reclamation. However, in practice the minimum anthracite bond is $1,000/acre and can exceed that level depending upon depth and local conditions.[2]

A special cost, which affects all coal mining, is the Black Lung Payments which are required by law. The Federal Coal Mine Health and Safety Act of 1969 provides that coal miners who are disabled by pneumoconiosis, and their surviving dependents in the case of death, receive a compensatory benefit. The Federal Government paid for this fund until 1973, when coal operators were required to contribute $3.61 per $100 of payroll of all workers. The share of the fund paid by operators has been scheduled to increase annually

---

[1] H. G. Bhatt, The Economics of Coal Mine Drainage Treatment, Michael Baker, Jr., Inc., Beaver, Pennsylvania, November 1973.

[2] Telephone Interview with Donald Zutlas, Chief, Licensing and Bond Division, Bureau of Surface Mine Reclamation, Pennsylvania Department of Environmental Resources. February 5, 1975.

by 25 percent for four years, until the coal mine operators and/or their insurers assume the entire cost of the fund.[1]

Comparable to the federal occupational disease legislation is Pennsylvania Act 337. The state Act became effective in July of 1973 and extended increased benefits to black lung claimants. The Act transferred the liability for the fund from the State Government to the coal operators in the same fashion as the federal legislation. To finance the first year of the fund, operators were required to contribute $9.48 per $100 of payroll. The operators' liability for the second level (financed 50 percent by state and 50 percent by operator) is still under negotiation.

Finally, development and finance costs merit consideration. Development costs in underground mines vary greatly depending upon the location, the size of the operation anticipated, and the use of previously established entries and gangways. Estimates for the development of a small deep mine have been placed at $250,000 for a 25,000 ton per year operation[2] in a virgin area. Large scale operations can involve in excess of $10 million and entail three or more years of effort before a production plateau is reached. Strip operations require substantial initial outlay as well. Some of the larger draglines currently in use in the anthracite industry are worth more than $5 million.

Fresh sources of investment capital will be required if the anthracite industry is to increase output significantly. Investment bankers and industrial coal users with substantial assets are two of the most promising agents.

Financing through mortgage banks, or bonds for larger projects, depends upon support from local development agencies as well as cooperation and interest on the part of banks. A local development authority can initiate a bond that would carry a tax free status. The banking community, however, is hesitant to proffer funds in an industry with uncertain markets. As a result, a lament has been expressed in interviews with coal operators that funds are often not available at favorable interest rates.

Financing by large anthracite consumers is a new area of promise to expanding anthracite operations. The purchase of Greenwood Stripping Company by Bethlehem Steel in 1974 indicates an interest on the part of consumers in supporting anthracite mining. In many cases, however, a long term contract with a large consumer would be sufficient to secure capital credit.

---

[1] "Analysis of Exposure Under Pennsylvania Act 337 Coal Mine Occupational Disease", J. Huell Brisese & Associates, Inc., Chicago, Ill., May 1973, p.1.

[2] Interview with E. Kieffer, Hegins Mining Company.

E. TRANSPORTATION

There are two stages to coal transportation: (a) from the mine to the breaker, and (b) from the breaker to the customer. The cost of the "internal" transportation from the mine to the breaker is incorporated in production costs. The generally greater price of shipping the prepared coal (stage b) is the responsibility of the customer. In the anthracite industry all domestic shipments in both stages are limited to truck or rail movements.

E.1 Mine to Breaker Transportation

The decisions of whether to use rail cars or trucks, and the loading method used in the first stage (mine to breaker) depends on several factors:

1. The method of coal extraction or recovery.
2. Equipment in use.
3. Distance from the mine site to the breaker.
4. The cost and availability of rails, hopper cars, highway routes, and trucks.

Rail shipments of raw (run of mine) anthracite in 1972 totalled 1.3 million tons.[1] Since 40 to 70 percent of the raw coal is translated into a marketable product at the breaker, the tonnage carried by truck in 1972 can be estimated at greater than 8.9 million tons. Truck shipments of raw anthracite have been growing relative to rail in the last 15 years. Two factors influenced the growth of truck transport in the mine to breaker stage of production. First, the relative gain in importance of strip mining as a source of raw anthracite has paralleled the heavier reliance on truck transport since a strip mine does not remain in one location, while a deep mine surfaces at one point. Secondly, since the average haul of anthracite from the mine to the breaker is relatively short,[2] truck shipments obtain an additional competitive advantage. As the distance hauled increases, rail rates per mile generally decline while truck rates remain somewhat constant.[3]

E.2 Breaker to Customer Transportation

Shipments from the breaker to the market originate in the loading pockets of the preparation plants. The loading plant must, in the process of trans-

---

[1] Freight Commodity Statistics, I.C.C., 1972.

[2] The rail trip from mine to breaker averaged 20 miles in 1961 according to the Distribution of Rail Revenue Contribution by Commodities, I.C.C., 1961.

[3] J. A. Vaughan, "Anthracite", Mineral Facts and Problems, U. S. Bureau of Mines, Bulletin 630, 1965, p.57.

ferring the coal to the railroad car or truck, strive to maintain a uniformity of consignments. This objective requires a minimization of degradation of sizes through breakage, a reduction of segregation, and maintenance of a uniform distribution of very good and off-grade coal among cars. Loading pockets are usually provided for all sizes of anthracite. Coal from the pocket is dumped directly into the cars, or from the pocket to a conveyor belt for loading at a central point. The coal can also be directly loaded from the cleaning screens of the preparation plant without intermediate storage.[1]

Once the truck or rail car has been loaded at the preparation plant, the destinations range from local markets in the Anthracite Region to nationwide and international markets. Local shipments to the immediate area accounted for 24 percent of all coal destined for market in 1972 (see Table II-12), and regional sales to the states of Pennsylvania, New Jersey, and New York absorbed 71 percent of all prepared coal in 1972 (Table II-13).

International shipments require that the coal be transported for loading into vessels at ocean ports or at the Great Lakes. Of the 717,000 tons of anthracite exported in 1973,[2] 3 percent was loaded at the Great Lakes. The bulk of loadings occurred at tidewater ports in Philadelphia and Baltimore. A more accurate gauge of loadings at ocean ports is available when U.S. military shipments of anthracite are included in the export total (437,000 tons in 1973), thus approximately 16 percent of all coal used in 1973 was eventually transported by water carriers.

E.3 Modal Split

Table II-13 represents the modal split between rail and truck deliveries of anthracite loaded at the preparation plants. Fifty-seven percent of the prepared coal was carried by trucks in 1973, and the remaining 43 percent was carried by rail. Canal and river shipments are non-existent in the anthracite industry. The relative growth of truck transportation since 1950 is apparent. In that year trucks handled less than one-fifth of all anthracite coal distribution, compared with 1973, when more than one-half of the coal was handled by trucks. The absolute volume of truck deliveries has declined, however, by 47 percent in the same time period. Rail deliveries fell by 91 percent from 1950 to 1973.

The bituminous coal industry shows a heavier reliance on rail transportation in recent years. Although 86 percent of bituminous coal was

---

[1] Coal Preparation, David R. Mitchell, ed., 1973.

[2] "Pennsylvania Anthracite Weekly", Mineral Industries Surveys, U. S. Bureau of Mines, March 8, 1974.

TABLE II-12

SHIPMENTS OF ANTHRACITE BY TRUCK AND RAIL (TONS)[1]

Domestic and Foreign
1968-1972

Destination	1968	1969	1970	1971	1972
TRUCK SHIPMENTS					
Pennsylvania:					
Within Region	2,021	1,918	1,847	1,880	1,584
Outside Region	2,269	2,151	1,979	2,050	1,793
New York	409	369	418	373	441
New Jersey	248	247	198	126	89
Delaware	26	22	18	17	15
Maryland	188	94	50	29	23
District of Columbia	2	2	2	[2]	[2]
Other States	18	17	15	12	21
Total	5,181	4,821	4,527	4,487	3,966
RAIL SHIPMENTS					
New England States	163	107	102	100	49
New York	606	645	455	532	281
New Jersey	263	291	173	113	85
Pennsylvania	846	940	847	819	830
Delaware	1	[2]	1	1	5
Maryland	32	34	19	24	2
District of Columbia	9	4	7	3	3
Virginia	6	6	9	7	3
Ohio	98	215	151	122	124
Indiana	43	70	66	54	42
Illinois	108	102	93	57	47
Wisconsin	14	6	12	8	10
Missouri	-	-	-	-	30
Minnesota	13	25	51	1	10
Iowa	-	-	-	-	31
Michigan	42	33	53	70	49
Other States	233	312	408	455	290
Total United States[3]	2,476	2,792	2,447	2,366	1,891
Canada	308	373	384	411	386
Other Countries	697	853	691	527	374
Total Rail[3]	3,481	4,018	3,522	3,347	2,651

[1]Compiled from reports of Pennsylvania Department of Environmental Resources; does not include dredge coal.

[2]Less than ½ unit.

[3]Data may not add to totals shown because of independent rounding.

Source: Minerals Yearbook, U. S. Bureau of Mines, 1972.

TABLE II-13

TRUCK AND RAIL SHIPMENTS OF ANTHRACITE

United States
Selected Years 1950-1973

Year	TRUCK			RAIL		
	Total Shipments (Tons)	Percent of all Truck Shipments Destined to Pa., NJ, & NY	Percent of all Shipments by Truck	Total Shipments (Tons)	Percent of all Rail Shipments Destined to Pa., NJ, & NY	Percent of all Shipments by Rail
1950	6,880,685	99	18	31,350,908	70	82
1955	8,050,298	99	30	18,357,270	69	70
1960	8,668,416	98	51	8,369,680	68	49
1961	8,642,551	98	53	7,818,598	69	47
1962	7,998,196	98	51	7,591,556	67	49
1963	7,970,106	98	50	7,979,392	53	50
1964	7,861,857	98	51	7,450,286	56	49
1965	6,811,607	98	51	6,421,919	54	49
1966	6,021,000	98	55	4,943,000	53	45
1967	5,312,000	97	56	4,136,000	50	44
1968	5,181,000	95	59	3,481,000	49	41
1969	4,821,000	97	54	4,018,000	46	46
1970	4,527,000	98	56	3,522,000	41	44
1971	4,487,000	98	57	3,347,000	43	43
1972	3,966,000	98	59	2,651,000	45	41
1973	3,775,551	-	57	2,835,309	-	43

Source: 1. Minerals Yearbook, U. S. Bureau of Mines, Selected Years.

2. "Pennsylvania Anthracite Weekly", Mineral Industry Surveys, U. S. Bureau of Mines, March 29, 1974.

shipped by rail in 1950, 66 percent was still being loaded into hopper cars in 1972. The bituminous industry also took advantage of inland waterways to transport 12 percent of its coal in 1972, and mine - mouth generating plants consumed an additional ten percent of the production.

E.4 Railroads

E.4.a Availability of Railroads

Six Class 1 railroads serve the Pennsylvania Anthracite Region. Of the six listed in the table below, Reading is the largest originator of anthracite shipments. In 1973, 2.2 million tons were loaded into Reading cars and 55 percent of all anthracite shipped by rail was carried on Reading lines.

TABLE II-14

CHARACTERISTICS OF RAILROADS

Pennsylvania Anthracite Region
1973

Railroad	Tonnage		Number of Deep Mines Served (3)
	Originated (1)	Carried (2)	
Central Railroad of New Jersey[1]	250,525	250,525	1
Delaware and Hudson Railway	274,471	332,273	3
Erie Lackawanna Railway Co.	62,000	232,000	1
Lehigh Valley Railroad Co.	780,780[2]	N/A	9
Penn Central Transportation Company	412,192	1,028,123	3
Reading Company	2,213,990	2,213,990	39
Total	3,993,958	N/A	56

[1]Central Railroad Company of New Jersey has discontinued operations in Pennsylvania. A subsidiary, Lehigh and New England Railroad, moved the reported tonnage.

[2]Estimated by Lehigh Valley Railroad officials.

Source: 1. Communications with individual railroads.
2. Testimony of the Economic Development Council of Northeastern Pennsylvania on Regional Rail Reorganization, EDCNP, March, 1974.

Column 3 of the above table indicates the number of deep mines operating in 1973 that were served by the individual railroads. This is no indication of all the anthracite producers using the rails, but only the deep mines which are served by rail heads.

The map on Plate II-16 shows the location of these railroads in the coal regions. The insert of the northeast United States rail network included on this map reveals the availability of connections from the Anthracite Region to major population and industrial centers. The strategic location of anthracite reserves, as well as the transportability, is readily apparent from this map.

E.4.b Conditions and Facilities of Railroads

On Table II-15 the six anthracite serving railroads are presented with a comparison of their facilities in 1955 and 1972. Since Penn Central Railroad Company and Erie Lackawanna Railway Company were not entities in their present form in 1955, a comparison would not be as straightforward. The four remaining rails evidence obvious deterioration of facilities. In every case, the number of locomotive units, freight cars, and total miles of railroad operated declined. Hopper cars, the predominant mover of coal, have experienced a precipitous withdrawal from service. Total hopper car stock of the railroads listed in columns 1 through 4 declined by more than 65 percent in the 17 year period. Column 3 of Table II-16, however, reflects the trend in the railroad industry today towards larger hopper cars. This shift from 70 to 100 ton cars partially offsets the loss of hopper cars in service since fewer cars are now required for an equivalent aggregate capacity. There is still, at present, a shortage of hopper cars which is expected to worsen. The situation is further aggravated by poor track maintenance and inefficient operation, which hamper coal movement.[1]

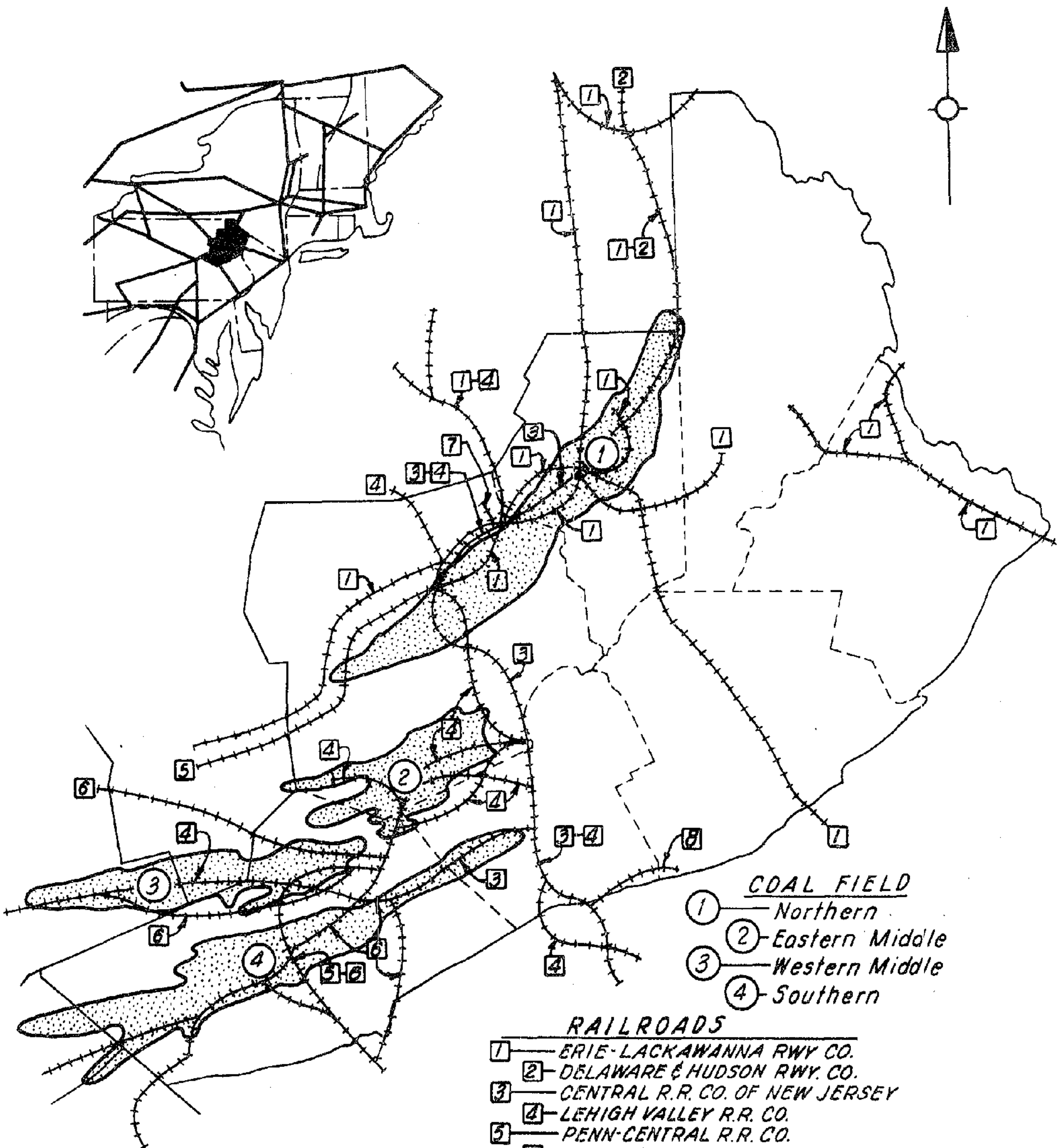
Paralleling the deterioration of rail facilities in the coal regions is the decline of anthracite tonnage shipped by rail. Column 3 of Table II-16 shows 80 percent less anthracite moved by rail in 1972 than in 1955. Coal traffic on all six railroads fell in the five year period from 1966 to 1971. The losses ranged from four percent on the Erie Lackawanna to 25 percent on Reading Railroad.[2] With such a loss of coal revenue (Table II-16, column 5) the rate of dissipation of rail service facilities for coal is not surprising.

---

[1]Pennsylvania Coal, Governor's Energy Council, E. Kline, Chairman, 1974, p.5.

[2]"Coal's Partner", Forbes, Vol.110, November 15, 1972, p.46.

MAJOR RAILWAY ACCESS
PENNSYLVANIA ANTHRACITE REGION
1974



SOURCES: Pa. Dept. of Commerce, Pa. Transportation Resources, 1970
The Official Guide of The Railways, National Railway Publication Co., 1972

PLATE II - 16

TABLE II-15

RAILROAD EQUIPMENT IN SERVICE

Railroads Serving the Pennsylvania Anthracite Region
1955 and 1972

Equipment in Service	Central Rail-road Company of New Jersey		Delaware and Hudson Railway		Reading Company		Lehigh Valley Railroad Co.		Penn Central Railroad Company*	Erie Lacka-wanna Rail-road*
	1955	1972	1955	1972	1955	1972	1955	1972	1972	1972
Locomotive Units										
Diesel (Beginning of Year)	182	138	179	117	354	250	223	151	3,898	552
Diesel (End of Year)	182	100	174	110	360	245	223	156	3,884	531
Electric (End of Year)	0	0	0	0	0	0	0	0	174	0
Other (End of Year)	34 (steam)	0	0	0	40	0	0	0	0	0
Freight Train Cars										
No. at Beginning of Year	10,512	3,521	11,609	5,571	30,310	14,142	15,380	4,976	166,250	22,069
No. at End of Year	10,038	2,771	10,608	5,380	29,004	13,302	15,284	4,270	164,702	20,670
Gondola (End of Year)	2,319	134	1,136	331	7,823	3,838	2,665	1,376	35,206	5,045
Hopper (End of Year)										
Open Top	4,249	290	5,956	1,420	13,016	5,188	6,022	127	47,960	2,396
Covered	482	1,128	434	325	582	907	591	847	10,543	1,521
Total Miles of Road Operated	613	402	792	717	1,307	1,171	1,150	972	19,861	2,864

*Not in Existence in 1955

Source: 1. Pennsylvania Transportation Resources, Department of Commerce, Commonwealth of Pennsylvania, 1970.
2. Eighty-Sixth Annual Report on Transportation Statistics in the U.S. for Year Ended December 31, 1972, I.C.C., Washington, D. C., Part 1

TABLE II-16

FREIGHT STATISTICS - PREPARED ANTHRACITE AND BITUMINOUS

United States
Selected Years 1955-1972

Year	Carloads (Anthracite)	Tons (Anthracite)	Tons/Carload (Anthracite)	Gross Freight Revenue (Anthracite)	Freight Revenue/Ton (Anthracite)	Freight Revenue/Ton (Bituminous & Legnite)
1955	367,309	20,661,437	56.25	$68,806,678	$3.33	$3.24
1960	175,135	9,899,596	56.53	36,620,902	3.70	3.40
1965	115,833	7,028,640	60.68	23,128,135	3.29	3.81
1966	103,393	6,352,991	61.45	23,347,778	3.68	3.01
1967	90,196	5,684,381	63.02	20,773,414	3.65	3.00
1968	76,827	4,826,301	62.83	19,131,788	3.96	3.01
1969	72,027	4,598,023	63.84	18,809,901	4.09	3.11
1970	55,859	3,533,927	63.27	17,830,315	5.05	3.42
1971	51,161	3,226,454	63.06	19,342,938	6.00	3.70
1972	40,429	2,550,614	63.09	16,556,463	6.49	3.67

Source: Freight Commodity Statistics, I.C.C., Selected Years.

Railroads in the past have been financially dependent on the coal industry for up to ten percent of their revenues. Relatedly, five of the six railroads listed in Table II-14 are presently bankrupt. One of these lines, the Reading Railroad Company, has expressed that if sustained coal movements could be reestablished the railroad could throw off bankruptcy and reorganize.[1]

Considering the present state of the rails, any revitalization of the anthracite industry will require a proportionate revitalization of the rails, especially if markets are developed outside the middle Atlantic states. As the Transportation Task Force Report of the Pennsylvania Action Conference on Coal stated: "Trucking coal is economically prohibitive over longer distances, and is ecologically unacceptable over any distance."[2]

E.4.c <u>Rail Reorganization</u>

The 1973 Federal Regional Rail Reorganization Act portends doom for the rail service of the Pennsylvania Anthracite Region. The United States Department of Transportation (DOT) and the United States Railway Association (USRA) have evaluated the rail lines in the northeast and have found the lines listed in Table II-17 to be "excessive". Plate II-17 is the visual presentation of these excess lines.

The excess trackage is under consideration for pruning to reorganize the rail system under government control. The new system is slated to begin operation as CONRAIL in 1976. According to the Pennsylvania Governor's Energy Council "The specter of abandonment of service and of rights-of-way in coal regions . . . is a nightmare of inept public and private policy."[3]

In four DOT zones in the Pennsylvania Anthracite Region (Zones 70, 71, 72 and 82) a total of 277 miles of track are listed as excess. Several operating collieries have been identified as being in jeopardy as a result of the railroad abandonment proposals. These collieries could be forced to cease operations if the trackage is discarded. The collieries listed in Table II-18 do not include recently closed ones that could be reopened under conditions of revitalization of the industry.

Deep mines are not the only coal operations affected by railroad elimination. In addition, a survey conducted by the Economic Development Council

[1] <u>Coal For the 70's, A Pennsylvania Action Conference</u>, Institute of State and Regional Affairs, I. Hand, Director, Harrisburg, Pennsylvania, April 24, 1974, p.201.

[2] Ibid.

[3] The Governor's Energy Council, op. cit., p.5.

TABLE II-17

POTENTIAL EXCESS TRACKAGE
DESIGNATED BY THE U. S. RAILWAY ASSOCIATION

Pennsylvania Anthracite Region
1974

OSPD No.	Name of Line	County	Railroad	Number of Miles
34	Branch to Glen Lyon	Luzerne	Penn Central Railroad Company	5.1
36	Freeland to, but not including, Jeddo	Luzerne	Lehigh Valley Railroad Company	2.3
73	Kulps west to Dornsife	Northumberland	Reading Company	12
75	Catawissa to Lofty	Columbia & Schuylkill	Reading Company	37
77	Westwood West through Tremont to Good Spring	Schuylkill	Reading Company	14
78	Tremont to Pine Grove	Schuylkill	Reading Company	6.8
79	Suedburg South to Lebanon	Schuylkill & Lebanon	Reading Company	0.75
81a	Delano to Raven Run	Schuylkill	Lehigh Valley Railroad Company	13.66
81b	Nesquehoning to Tamanend	Schuylkill	Lehigh Valley Railroad Company	13.3
197	Scott Branch from Brady North to Terminus	Northumberland	Penn Central Railroad Company	1.9
198	Green Ridge Branch from Shamokin Secondary North to Sagon Junction	Northumberland	Penn Central Railroad Company	1.4
200	Coirard Mammoth-Colliery Branch	Schuylkill	Reading Company	1.63
201	Locust Gap Colliery Branch	Northumberland	Reading Company	0.42
202	Schuylkill Valley Branch at Middleport	Schuylkill	Reading Company	0.12
204	Section of Watsontown Secondary in Berwick	Columbia	Penn Central Railroad Company	0.3
208	Pink Ash Junction to beyond Jeddo	Luzerne	Lehigh Valley Railroad Company	3.2
209	Nesquehoning Junction North to Glen Onoko	Carbon	Lehigh Valley Railroad Company	0.8
211	Branch to Nanticoke	Luzerne	Penn Central Railroad Company	6.8
212	Franklin Branch at Wilkes-Barre	Luzerne	Lehigh Valley Railroad Company	1.04
213	Haucks Junction to Tamanend	Schuylkill	Lehigh Valley Railroad Company	0.8
214	Nesquehoning West to Schuylkill County Line	Carbon	Lehigh Valley Railroad Company	4.6
216	Laurel Junction South through Newton to Rock	Schuylkill	Lehigh Valley Railroad Company	9.6
219	Schuylkill Secondary from Pottsville Southeast to Berks County Line	Schuylkill	Penn Central Railroad Company	12.0
263	Shamokin Secondary Track From Sunbury Southeast to Mount Carmel	Northumberland	Penn Central Railroad Company	25.6
275	Hudson to Buttonwood	Luzerne	Penn Central Railroad Company	7.4
276	Buttonwood Branch from Sunbury to Wilkes-Barre	Northumberland, Montour Columbia & Luzerne	Penn Central Railroad Company	63.0
278	St. Clair to Bear Run Junction	Schuylkill	Reading Company	8
279	Catawissa to Rupert	Columbia	Reading Company	2.4
280	Lorberry Junction to Terminus	Schuylkill	Reading Company	2.6
281	Tremont to Terminus	Schuylkill	Reading Company	0.2
282	Swatara Junction to Terminus	Schuylkill	Reading Company	1.6
283	Silverton to West Junction	Schuylkill	Reading Company	N/A
290	Good Spring to Terminus	Schuylkill	Reading Company	N/A

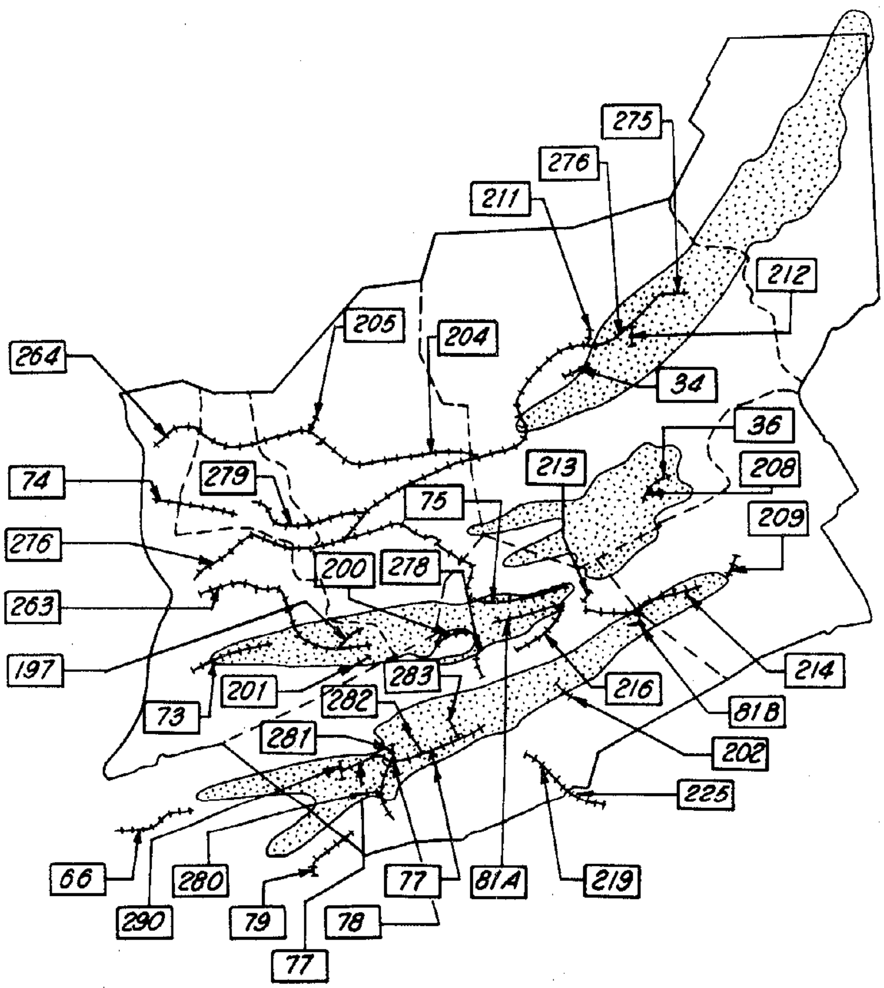
Source: Pennsylvania Office of State Planning and Development, "Analysis to Date of 'Potentially Excess Rail Lines' Designated by the U. S. Railway Association", December 9, 1974.

POTENTIAL EXCESS TRACKAGE

(U.S. DEPARTMENT OF TRANSPORTATION, U.S. RAILWAY ASSOCIATION)

PENNSYLVANIA ANTHRACITE REGION

DECEMBER – 1974



SOURCE: Pa. Office of State Planning and Development, "Railroads of Penna." December, 1974

PLATE II - 17

TABLE II-18

COLLIERIES JEOPARDIZED BY RAIL REORGANIZATION PROPOSALS

Pennsylvania Anthracite Region
1974

Colliery	Zone	Ownership	Railroad	Trackage in Miles
Huber	72	Blue Coal Company[1] Ashley, Pa.	Lehigh Valley Railroad Company Ashley Outbound	7
Wanamie	72	Blue Coal Company[1] Ashley, Pa.	Lehigh Valley Railroad Company Wanamie/Blue Coal Spur	4
Jeddo No.7	72	Lehigh Valley Coal Co. W. Pittston, Pa.	Lehigh Valley Railroad Company Ashmore to Jeddo	4
Hazleton Shaft	72	Lehigh Valley Coal Co. W. Pittston, Pa.	Lehigh Valley Railroad Company Ashmore to Jeddo	4
Eckley	72	Buckley Coal Company Weatherly, Pa.	Lehigh Valley Railroad Company Eckley to Drifton	2
Beaver Brook	72	Buckley Coal Company Weatherly, Pa.	Lehigh Valley Railroad Company Beaver Brook Vertical	4
Gowen	72	Gowen Coal Company Fern Glen, Pa.	Lehigh Valley Railroad Company Gowen to West Hazleton	10
Lion	72	Lehigh Valley Coal Co. W. Pittston, Pa.	Lehigh Valley Railroad Company Ashmore to Jeddo	4
Tamaqua	72	Greenwood Coal Co. Tamaqua, Pa.	Lehigh & New England Railroad Spur South to Hauto	6
Trevorton	82	Reading Company Pottsville, Pa.	Reading Company Trevorton to Shamokin	9

[1]Blue Coal Company ceased operations in 1974.

Source: "Testimony of the Economic Development Council of Northeastern Pennsylvania on Regional Rail Reorganization", Economic Development Council of Northeastern Pennsylvania, March 12, 1974, page I-A.4.

of Northeast Pennsylvania (EDCNP) identifies ten coal companies which "Must have rail service to exist".[1] The companies (which include strip and bank operations) accounted for 43 percent of all the anthracite production in 1973. One of the ten companies, The Buckley Coal Company, is the fastest growing company in the region.[2] The Company plans to erect the region's first calcinating plant to process anthracite for use in the aluminum industry. The abandonment of trackage from Eckley to Drifton, a total of two miles, would force The Buckley Coal Company to close down.

Pagnotti Enterprises and its subsidiary companies are primarily strip operations, which tallied the largest single production of anthracite in 1973. Approximately 55 percent of the coal from the Lehigh Valley operation was delivered to market by rail. Executives of Pagnotti Enterprises indicated that rail service is essential to continued operation.

The Rail Reorganization Act specifies that "Existing railroad trackage in areas in which fossil fuels and natural resources are located" should remain intact.[3] In spite of the intent of the act, the U.S.R.A. "Preliminary Plan" still recommends that certain of the anthracite serving rails not be included in the ConRail System.[4] The disgrace of abandonment will emerge should future expansion of anthracite output in the entire region be contained by inadequate rail service.

E.4.d Rail Rates

Bulk transport rates of coal have traditionally added an appreciable increment to f.o.b. mine prices. In Plate II-18 the sales realization of anthracite at the preparation plant is compared to the average national freight rate for anthracite shipments. The total cost of extraction and preparing coal in 1972 was approximately twice the cost of transporting it to market.

Rail rates have remained near half the sales price for the last twelve years. The recent increase in coal prices (see Chapter III, p.4) will, for 1974, relegate the rail additive to a lesser order of importance.

---

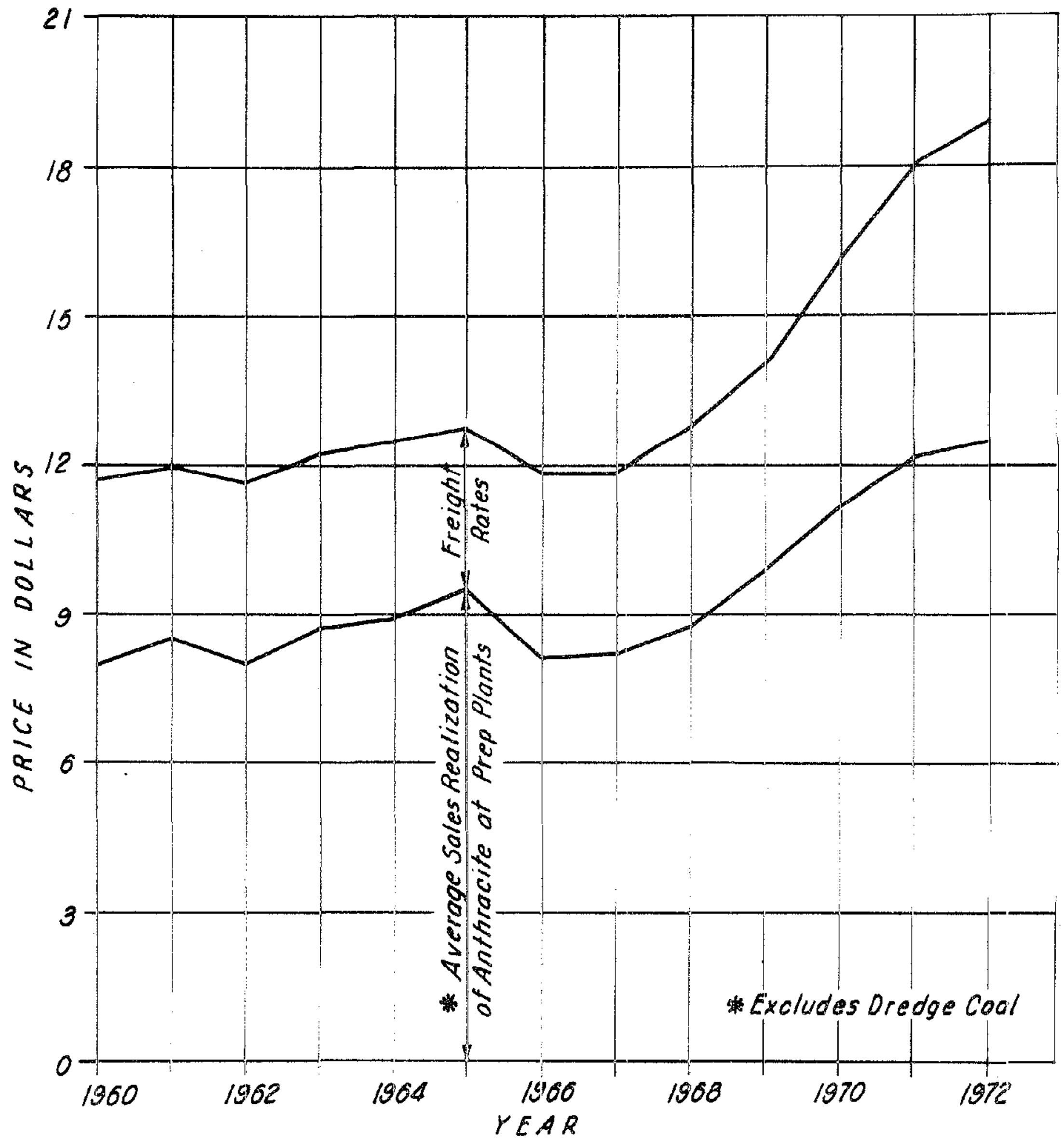
[1]The Economic Development Council of Northeastern Pennsylvania, op. cit., Exhibit 3, appendix I-A.

[2]Ibid.

[3]Evaluation of the Secretary of Transportation's Rail Service Report, I.C.C., May 2, 1974, p.33.

[4]The U.S.R.A. Preliminary System Plan became available after the analysis of the rail section. The Preliminary Plan modifies both Plate II-17 and Table II-17. See U.S.R.A., Preliminary System Plan, February 26, 1975, especially Volume II, p.711-799.

AVERAGE SALES REALIZATION AND FREIGHT RATES OF ANTHRACITE
UNITED STATES
1960 — 1972



SOURCES: U.S. Bureau of the Mines, Minerals Yearbook, Selected Years. I.C.C., Freight Commodity Statistics; Class I Railroads in the U.S., Selected Years.

PLATE II - 18

Rail rates are based upon a series of components with mileage seldom the primary determinant. Factors which will affect rates include:

1. The presence of competition of trucks to given rail destinations.

2. The weight of the rail cars, with greater capacity of hopper cars, the lower the rate.

3. The ownership of coal cars.

An additional influence on coal rates is the type of rail coal movement utilized. Coal is hauled in single cars or any of three basic bulk shipments. The bulk rate applies to a shipment from two or more points of origin with a definite minimum tonnage per train required in order to qualify for a special rate. Unit train movements arise from a single origin, and terminate at a single destination. Integral trains, or shuttle trains, consist of a unit of cars and motive power which remains coupled in the entire shipping process. All three of these discount shipping methods are part and parcel of bituminous movements. Anthracite hopper cars, on the other hand, are never joined in bulk shipments, yet the single car method is generally more expensive. The relatively smaller output of anthracite mines would not eliminate the possibility of using bulk movements if assembly point plans or half train rates were introduced.[1]

Anthracite rail movements are also handled in smaller car loads. For the five year period from 1967 to 1972 anthracite hopper cars have carried an average of 13 less tons per car than bituminous. The combination of smaller car loads and single car rates partially explain the high cost of moving anthracite. Although anthracite rates are generally based on a shorter distance haul than bituminous, the average rate in cents per ton mile for anthracite traffic exceeds that of bituminous. In columns 5 and 6 of Table II-16, bituminous and anthracite rates are compared for recent years. In every year except 1965 the rate for bituminous coal has been lower than that of anthracite. Since 1965 the average rate for anthracite per ton has almost doubled. In the same period bituminous rates per ton have declined 14 cents.

Table II-19 presents typical 1974 freight rates for anthracite and bituminous coal expressed in dollars (column 4) and mills per ton mile (column 5). Difficulties arise in comparing freight rates because they are a function of many variables. Mileage is, nonetheless, the primary

---

[1]Rail officials cite two reasons why assembly point plans are not used: (1) they could not supply enough hopper cars at once and, (2) too few anthracite shipments are of sufficient volume and destined to a single customer to warrant the unit train movement.

TABLE II-19

TYPICAL FREIGHT RATES - ANTHRACITE AND BITUMINOUS

United States
1974

From	Via	To	Miles	Rate/Net Ton	Rate in Mills/ ton mile
ANTHRACITE COAL[1]					
Locust Summit, Pa.	Reading	Benson Mine, N.Y.	557	$8.15	14.6
Gilberton, Pa.	Reading	Ironton, Ohio	704	9.86	14.0
Locust Summit, Pa.	Reading	Parsons, W. Va.	366	8.01	21.9
Tremont, Pa.	Reading	Wrentham, Mass	450	8.03	17.8
Shamokin, Pa.	Reading	Philadelphia, Pa.	138	5.02	36.4[2]
Shamokin, Pa.	Reading	Wilmington, Dela.	152	5.72	37.6[2]
Shamokin, Pa.	Reading	Bethlehem, Pa.	120	3.67	30.6[2]
Shamokin, Pa.	Penn Central	Philadelphia, Pa.	187	5.02	26.8[2]
Scranton, Pa.	Erie Lackawanna	Binghamton, N.Y.	68	3.25	47.8[2]
Scranton, Pa.	Erie Lackawanna	Youngstown, Ohio	424	7.81	18.4[2]
Average Unweighted Miles			316.6		
Average Unweighted Mills/ton mile					26.6
BITUMINOUS COAL					
Clearfield, Pa.	Penn Central	Philadelphia, Pa.	314	$7.76	24.7[2,3]
Clearfield, Pa.	Penn Central	Baltimore, Md.	266	7.76	29.2[2,3]
Clearfield, Pa.	Penn Central	Carthage, N.Y.	414	8.54	20.6[2,3]
Ebensburg, Pa.	Penn Central	Bethlehem, Pa.	269	7.13	26.5[4]
Ebensburg, Pa.	Penn Central	Lackawanna, N.Y.	260	6.89	26.5[2,4]
Johnstown, Pa.	Penn Central	Swedeland, Pa.	263	6.89	26.2[2,4]
Grant Town, W. Va.	Penn Central	Eddystone, Pa.	451	6.12	13.6[5]
Philipsburg, Pa.	Penn Central	Dresden, Pa.	255	5.72	22.4[2,5]
Clearfield, Pa.	Penn Central	Dunkirk, N.Y.	215	5.32	24.7[2,5]
Fairmont, W. Va.	Penn Central	Rochester, N.Y.	430	5.84	13.6[5]
Average Unweighted Miles			313.7		
Average Unweighted Mills/ton mile					22.8

[1]All anthracite movements are single car shipments.
[2]Shipments originated and terminated on line.
[3]Single car shipment.
[4]Volume shipment (1,500 tons one origin - 5,000 tons more than one origin).
[5]Trainload shipment (7,000 tons - one or two origins).

Source: Written comments from individual railroads.

determinant of rates. The mileage upon which these rates are constructed are comparable - 317 miles for the unweighted average anthracite haul, compared to 314 miles for the unweighted average bituminous haul. The rates, however, are not as comparable. Bituminous rates enjoy a 14.3 percent advantage over anthracite rates.

The influence of single car versus bulk shipments can be removed and the rate disparity still exists. All of the anthracite rates are based on a single car rate, while the first three bituminous rates are single car, yet the average 2.48 cents per ton mile is less than the average anthracite rate. Price discrimination against anthracite coal as compared to bituminous in rail rates appears as much alive today as it did in 1938 when the Pennsylvania Anthracite Coal Industry Commission found anthracite rates excessive (Chapter I, p.22).

E.5 Trucks

Truck shipments from the breakers, reported by the U. S. Bureau of Mines in 1973, amounted to 3.8 million tons. These deliveries from the breaker generally moved to the local market for sales. The preparation plant operator either sold his product to the truckers, who sold it to retail dealers, or it could be sold directly to the retailers or customers. Ninety-nine percent of truck shipments were destined for the mid-Atlantic states in 1973, with the bulk remaining in Pennsylvania.

The shift from rail to truck shipments in the last quarter century has been dramatic. The trend from 1950 to 1973 is apparent from Table II-13. Mr. J. Vaughan commented on this trend using 1948 to 1962 statistics. He cited the following cause for the transition:

1. The relative stability of the market in the producing region.
2. Increased rail freight rates.
3. Larger truck capacities.
4. Improved highways.
5. Shorter turn around time between mine and consumer.
6. Greater flexibility in retail dealer operations.[1]

Of these six propositions only the first one is no longer valid today. In the decade from 1962 to 1972 the percent of all shipments to markets within the Pennsylvania producing region declined from 43 percent to 40 percent while Western markets grew slightly. None the less trucking has continued to grow in relative importance for distributing the anthracite.

---

[1]J. Vaughan, "Anthracite", Mineral Facts and Problems, U. S. Bureau of Mines, 1965, p.57.

Road conditions have improved, primarily from the introduction of the Interstate Highway system to the Anthracite Region in the last two decades. Plate II-19 shows the major highways in the coal region as well as the Interstate highways (80, 81, 84, and 380) which converge, with the Pennsylvania Turnpike, in the anthracite area. The net result is easy access to major cities on the east coast with the system providing direct links to New York City, Philadelphia, Baltimore, Syracuse and Harrisburg. All these destinations are less than 200 miles from Scranton in the Northern Coal Field.

E.6 Transportation Capabilities Evaluated

Present production of anthracite coal is not restrained by inadequate transportation. The threat of rail abandonment could alter this picture by leaving several mines and breakers idled by severance from their markets. Increased production of anthracite would be discouraged by an emasculated railroad.

Although the modal shift from rail to trucks could continue, the current demand for land and energy use efficiency militates against it. Rail fuel efficiency was assessed by the Battelle Institute Study.[1] The exhaust emission per ton mile of freight moved by truck was found to be more than three times the emission for rail. The railroads are also more efficient land users, occupying about seven percent of the land that highway rights-of-way occupy. The future of rails will influence the anthracite industry. Should production of anthracite expand significantly both truck and rail carriers will have to share the increased load.

F. LEGISLATION

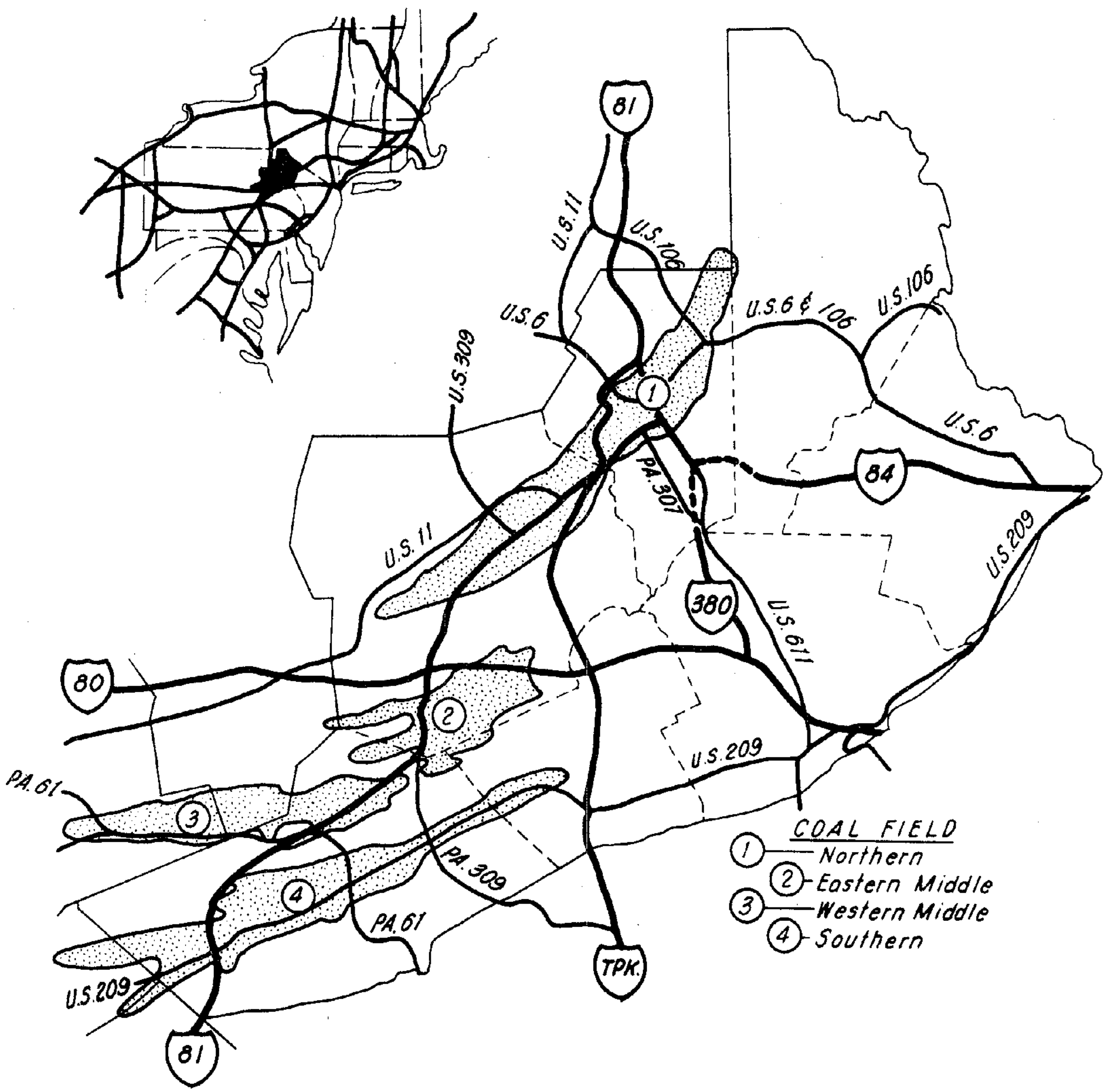
This section examines some of the legislation that is pertinent to anthracite mining, and, where appropriate, comments on the effect of this legislation on the industry.

President Gerald R. Ford, in his January 15, 1975 State of the Union Address, commented that he intended to seek amendments to the Energy Supply and Environmental Coordination Act which would encourage power plants to convert to coal, and to the Clean Air Act which will allow greater coal use without sacrificing clean air goals. President Ford has requested planning for 250 major new coal mines, and 150 major new coal-fired power plants.

---

[1] Evaluation of the Secretary of Transportation's Rail Service Report, op. cit., p.33.

MAJOR HIGHWAY ACCESS
PENNSYLVANIA ANTHRACITE REGION
1974



SOURCE: "Pa. Official Transportation Map", Pa. Dept. of Transportation, 1974, "Public Roads" vs. Department of Transportation, Vol. 38/No. 1, 1974

PLATE II - 19

Even though the Administration desires that energy users be directed away from oil and into more diversified sources, a moratorium has been placed on federal spending on all but those projects essential to expanding energy resources. The priorities specify the development of synthetic fuels from oil shale and coal derivatives. A goal has been established to secure one million barrels per day in 1985, using technologies presently nearing commercial application.

F.1 National Environmental Policy Act of 1969

The National Environmental Policy Act established the Council of Environmental Quality (CEQ) and granted all federal agencies a mandate to consider the environmental impact of their actions.

The Council consists of three persons who report directly to the President and are charged with the responsibility of appraising environmental trends and to recommend national policies concerning the conservation, social, economic and health goals of the nation. The Council publishes an annual report concerning the state of the nation's environment. An Office of Environmental Quality has been established to support CEQ with a professional and administrative staff.

The CEQ through the 1969 Act will have the responsibility to evaluate and report to the President its findings concerning the environmental effects of any future National Energy Policy.

F.2 Federal Energy Administration Act of 1974

On May 2, 1974, President Richard M. Nixon signed the Federal Energy Administration Act of 1974, and charged its Administrator with "establishing a comprehensive national energy policy" and assessment of the adequacy of energy resources for the future.

The Federal Energy Administration (FEA) is to serve until June 30, 1976, and six months prior to termination is to supply the Congress with recommendations for an organization of the Government to manage energy and natural resources policies and programs.

In December 1974, an interim Comprehensive Energy Plan was submitted to the Congress which did identify six national energy goals but did not establish a long term policy. Energy research and development plans were not submitted because they would yield ". . . no appreciable impact upon (the) energy supply for the next two years".

Oil and gas are to be reduced as primary energy sources in favor of coal (if the user finds coal a feasible alternative). The majority of programs to relieve energy problems are directed to reducing oil imports and initiating the acceleration of nuclear energy. The desired total coal production for 1976 is 741 million tons.

F.3 Energy Supply and Environmental Coordination Act of 1974

On June 24, 1974 the Energy Supply and Environmental Coordination Act gave the Federal Energy Administrator the authority to prohibit any power plant, and may possibly prohibit any major fuel burning installation, the privilege of burning natural gas or petroleum products as its primary energy source if the plant has the present capability to burn coal.

The Environmental Protection Agency (EPA) has been designated as the Administration to determine which facilities are not exceptions to the law and to certify the earliest date that the consumers should begin to use coal as their primary fuel source.

Power plants and major fuel consuming installations (with some exceptions) may be required by the FEA to design for coal as the primary energy source.

This Act may provide new markets for anthracite as a fuel in regions where it can compete with bituminous coal as a proposed fuel.

F.4 The Clean Air Act of 1965 (Amended 1970 and June 1974)

The Clean Air Act legislates against air pollution and originates a national research and development program to protect and maintain clean air standards.

The Administrator of the Act is directed to give special emphasis to R & D projects which relate to fuel combustion, combustion by-products, potential air pollutant removal, emissions control, and combustion efficiency.

The Clean Air Act Amendments of 1970 established areas designated as air quality control regions and provided standards for air quality control criteria. Air pollutants were identified as those factors which affect the public health or welfare in an adverse manner.

Each state was directed to enforce its own standards of air pollution for stationary sources located within its boundaries.

In 1974 the Act was amended to give the Administrator of the Environmental Protection Agency authority to determine the emission limitations and requirements with respect to the pollution characteristics of coal. The EPA is to monitor the burning of coal and provide that no harmful emissions result which would be in excess of air quality standards.

In order to support the conversion from burning gas and oil products to coal as required by the Energy Supply and Environmental Coordination Act, the Environmental Protection Agency has been tasked to identify and certify those energy users who will be burning coal or coal by-products as their primary power source.

A statement issued by the National Coal Association,[1] forecasts that annual coal production will require doubling by 1985. The net result will be an additional $21 billion investment in new mines, as well as jobs for some 80,000 new miners.

The 1974 Amendments to the Clean Air Act appear to ensure a future for coal, but the industry will have problems meeting current regulations. Almost one-half of the bituminous coal available does not meet EPA emission standards and the costs to clean the high-sulphur coal can dramatically increase the burning price to the consumer.

Anthracite coal, while it is presently more expensive to mine, could be developed as an important fuel source for the northeast regional power plants and major energy users. In many cases, anthracite sulphur levels are well below EPA standards, and any energy user's design of a stationary source which burns anthracite will either eliminate or greatly reduce the costs of scrubbers presently required on the bituminous burning stacks.

F.5 Energy Reorganization Act of 1974[2]

On October 11, 1974, President Gerald R. Ford signed the Energy Reorganization Act of 1974 which established the Energy Research and Development Administration (ERDA). Under the new law the Atomic Energy Commission, the Office of Coal Research, and branches of the Bureau of Mines, the Environmental Protection Agency, and the National Science Foundation have been combined into a new administration. ERDA is to have a projected staff of 7,000 with a $10 billion, five year R & D program; 6,000 of the personnel and 84 percent of ERDA's 1975 budget will come from the Atomic Energy Commission.

The Assistant Administrator for Fossil Energy will be responsible for developing new fuel technology. A significant number of coal associated programs are directed to liquefaction, gasification, and control technology.

F.6 Non-Nuclear Energy Research and Development Act of 1974

The Non-Nuclear Energy Act (signed December 31, 1974) states that as much as $20 billion in federal research funds may be required to develop non-nuclear energy technology in the next decade. The Act emphasizes that time is of the essence and that crash programs which explore conceivable technologies will have to be employed.

---

[1] "The Impact of the Clean Air Act on the U. S. Coal Industry: The Problem and its Solution", National Coal Association, 1974.

[2] "Weekly Review #62", Energy Users Report, October 17, 1974.

The Administrator of the Energy Research and Development Administration is charged with the responsibility of governing the Act. His primary purpose will be to conduct a national program of both applied and research projects emphasizing application of energy sources and energy utilization techniques.

The development of low sulphur boilers, coal gasification, coal liquefaction, and in situ coal gasification are projects mentioned specifically in the Act which would enhance coal development.

The improvement of existing energy systems through various management devices are supported; however, the Act does not appear to readily endorse the research and development of new raw material recovery techniques. The Act does appear to emphasize research for power systems, such as coal gasification. Mining is to be expanded by improving current recovery applications. Whereas the bituminous deep mining industry could possible carry over some of its advanced mining studies from Bureau of Mines R & D projects, there are no such projects keyed to anthracite. A major problem will be to receive funds under this Act for improving anthracite deep mining technologies, unless they are to directly support an energy source demonstration project.

F.7 Federal Coal Mine Health and Safety Act of 1969

The Federal Coal Mine Health and Safety Act of 1969 established that "The first priority and concern of all in the coal mining industry must be . . . the miner", and that the purpose of the Act is to:

1. Establish mandatory health and safety standards.
2. Require coal mine operators and miners to comply with such standards.
3. Provide assistance to and cooperate with the states in developing and enforcing state health and safety programs.
4. Improve and expand, in cooperation with both the state and industry, research and development and training programs aimed at preventing coal mine accidents and occupational diseases.

Authorized representatives of the Secretary of the Interior are directed to enter the mines and to cite violations which have been found during the process of inspection. All violations, minor or major, are subject to assessment.

If the inspection determines a violation that is an imminent danger, the inspector has the authority to order the mine closed until the hazard is corrected.

The Act established health and safety standards for all phases of both surface and underground mining operations. The coverage includes:

1. Medical Examinations
2. Respiratory Equipment
3. Dust Control
4. Noise Control
5. Roof Supports
6. Ventilation
7. Combustible Materials
8. Electrical Equipment
9. Trailing Cables
10. Fire Protection
11. Maps
12. Blasting and Explosions
13. Hoisting
14. Emergency Shelters
15. Communications.

The Act also administers the "Black Lung Program" through the Secretaries of Health, Education and Welfare, and Labor.

The Mine Enforcement and Safety Administration (MESA) has been established in the office of the Secretary of the Interior to specifically carry out the provisions of the Act. The anthracite industry is under the jurisdiction of the Division of Health and Safety, District 1, located in Wilkes-Barre, Pennsylvania.

It has been the opinion of most operators, engineers, and consultants interviewed, who have been involved in anthracite mining, that with few exceptions the law is geared to bituminous coal mines. Some of these standards have in effect placed a severe burden on the smaller operators who account for most of the deep mined coal.

When the 1969 Act was in the drafting stage, there was for the most part no representation or contribution from those actively involved in the anthracite industry. There were some "after-the-fact" meetings with the hard coal operators, but basically these meetings were merely a review of the law as it was enacted and little or nothing was accomplished which would adapt the regulations to peculiarities of anthracite mining.

In September, 1971 the Secretary of the Interior established The Advisory Committee on Safety Standards for Anthracite Coal Mines. The committee membership was composed of individuals qualified to evaluate the 1969 Act as it applied to Pennsylvania anthracite. In 1972 this committee submitted its proposed amendments to the Secretary (see Appendix to Chapter II).

In May, 1974 MESA established the Anthracite Task Force which in effect has replaced the functions of the Anthracite Advisory Committee. The Task Force has been charged with the responsibility of studying the entire spectrum of mine safety as it applies to hard coal mining.

The absolute enforcement of standards concerning ventilation, electrical wiring, and hoisting equipment has apparently created both technical and financial problems within the mines which cannot be readily solved or whose cost cannot be passed along to the consumer. The operator is then forced to work at either a reduced production rate, lower profit margin, or could possibly cease operations.

The standards concerning ventilation, safety catches, and automatic couplers have been the most difficult problems to solve in the deep mines and the inability to reach the proposed standards are essentially of a supply or economic nature. Recognizing this problem, the MESA officials who regulate the law for anthracite have relaxed certain conditions concerning ventilation and monitoring devices, fan operation schedules, hoisting problems, safety catches and to a certain extent electrical wiring. This relaxation has occurred on an individual mine by mine basis. Each case must be evaluated on its own merits.

MESA officials are quick to point out that the 1969 Act is a law passed by Congress and that MESA is charged with upholding the law and its regulations, as written. In a recent interview Mr. James M. Day, MESA's Administrator, discussed the proposed revisions to the law which will be introduced to Congress in early 1975 as an administration bill. The two major changes would concern, first, the elimination of mandatory fines for minor or incidental violations, and in its stead a warning notice would be issued. Second, the "De Novo" review of assessments currently permitted by district courts would be eliminated. The De Novo trial has been a delaying tactic used by mine operators to receive an entire new trial on violations rather than utilizing the courts of appeal.

The Department of the Interior is required by the Act to cooperate with the industry to provide technical assistance, along with research and development, in order to improve health and safety. Currently a technical support group has been established in Pittsburgh to provide the prescribed expertise. However, for various reasons, the personnel assigned have been able to assist the bituminous coal mines to a far greater extent than the anthracite mines. The lack of anthracite activity within the Pittsburgh group has resulted in the formation of an in-house technical support group in District 1 specifically serving the anthracite mines. The stated purpose of this group has been "immediate answers for immediate problems", and it is not anticipated that any research and development projects will be attempted.

F.8 <u>Federal Water Pollution Control Act of 1972</u>

This Act states, in part:

> The objective of this Act is to restore and maintain the chemical, physical, biological integrity of the nation's waters. In order to achieve this objective, it is hereby declared that . . . it is the national goal that whenever attainable an interim goal of water quality

which provides protection . . . shall be achieved by 1983. It is the national policy that the discharge of toxic pollutants in toxic amounts will be prohibited.

In order to carry out the objectives of this Act, there shall be achieved, not later than July 1, 1977, effluent limitations for point sources which require the application of the best practicable control technology currently available, ... Not later than July 1, 1983 effluent limitations . . . shall require application of the best available technology economically achievable . . . which will result in further progress towards the national goal of eliminating the discharge of all pollutants.

The states have been directed to locate, identify, and propose treatment methods for all sources of water pollution (including those which are mine-related) within area-wide regions. The overall treatment plans are to include not only the proposed potential polluting sources but those abandoned as well. The Environmental Protection Agency has established minimum water quality criteria but does not limit the states from maintaining even more stringent requirements.

F.9 Appalachian Regional Development Act of 1965

The Act acknowledges the Appalachian region of the United States as one which is abundant in natural resources but lags behind the nation in economic growth. An Appalachian Regional Commission has been established with the purpose to develop, encourage, conduct, and sponsor coordinated programs which will help develop the region.

Mining areas within the region which have been disturbed and abandoned may be reclaimed with Appalachian funding in conjunction with the participating state. These funds are essentially to be used for restoration when they can be related to economic growth, recreation facilities, public health and safety, erosion control, flood control, etc.

The Commission is authorized to make a survey and study of mine acid pollution and to estimate the economic or social benefits which would be likely to occur from reducing the pollution levels in Appalachia's streams.

The Appalachian Regional Development Act has the authority to assist with programs concerning highways, health centers, erosion projects, mine area restoration, housing, airport safety, vocational education and sewage treatment. All of these programs require State participation in the project.

With the exception of certain erosion control plans, there are no provisions under this Act to provide support or promote the economic development of small individual private mining interests within the region.

F.10 Pennsylvania Anthracite Coal Mine Act of 1965 (P.L.721)

This Act has consolidated some 18 earlier statutes and has combined their most pertinent and relevant regulations into a single law affecting deep mines and preparation plants.

The 1965 Act gives the Pennsylvania Secretary of Environmental Resources the authority to establish anthracite mining districts, appoint qualified mine inspectors and certify miners. The Act establishes the health and safety qualifications for each supervisory position within a mine, delineates the minimum acceptable standards required for health and safety in mines, and provides for a record keeping procedure for mining operations. The law does provide both civil and criminal penalties for violations of the Act.

When the Federal Coal Mine Health and Safety Act of 1969 became law, the health and safety aspects of the Anthracite Coal Mine Act were superseded, for the most part, with stricter federal regulations.

The Federal Act requires automatic assessments for violations regardless of the severity while the Commonwealth of Pennsylvania law requires only that the mine inspector report his findings to the Secretary in writing. Both the federal and state inspectors do have the authority to stop work in the mine for imminent hazards. The Commonwealth inspector does have the power by law to "Exercise sound discretion in the performance of his duties" while federal inspectors are required by law that if "There has been a violation of any mandatory health or safety standards, he shall issue a notice to the operator . . .".

The law is in conflict with the Mine Enforcement and Safety Administration (MESA) concerning roof supports. Pennsylvania requires that timber spacing not exceed six feet, while MESA requires five feet or less of spacing. In the older mines retimbering to new dimensions can be a significant and expensive problem.

Even more significant, the Anthracite Coal Mine Act identifies the distinction between gaseous and non-gaseous mines. MESA regulations are based on the assumption that all mines are gassy.

One significant constraint to the advancement of mining technology in anthracite is the stringent procedural requirements placed on the use of roof bolts (Section 271). The operator of each mine that desires to use roof bolts is first required to have approval of three mine inspectors and permission, in writing, from the Commissioner of Deep Mine Safety.

F.11 The Clean Streams Law of Pennsylvania (1970)

Pennsylvania's Clean Streams Law gives the Department of Environmental Resources, through the Environmental Quality Board, power to evaluate the state's water resources, and to regulate polluting discharges into the streams by establishing quality standards. These standards are used to determine the limits of effluent contamination before designating an industry as a polluting source. The law states that no industrial waste shall be permitted to flow or discharge untreated into Pennsylvania streams, and that all treatment facilities for handling polluted waste shall be approved by the Department.

Specifically concerning coal mining the law states "No person . . . shall operate a mine or allow a discharge from a mine into the waters of the Commonwealth unless such . . . discharge is authorized by the rules and regulations of the board . . . .". The law covers only those mines which were operating on or after January 1, 1966, and regulates discharge controls during active operations and after mining ceases.

The land owner is held liable for all polluting discharges from his property unless it can be proven that the pollution is the cause of an Act of God that has occurred after a completed and approved conservation plan has been accepted by the Department.

More than 80 percent of the known coal reserves in the anthracite fields are inundated with more than 91 billion gallons of water from approximately 160 major deep mine pools. In 1948, a period when the current industry production was nearly ten times that of the present, over 200 billion gallons of water were pumped annually. Water in the existing mine pools will be a constant problem if the inundated reserves are to be recovered. It is reasonable to expect that pumping conditions will be no better in the future should mining activity increase, and annual rates may match or exceed 200 billion gallons annually. This huge volume of water will come under the Clean Streams Act and will be required to meet the standards set by the Environmental Quality Board.

F.12 Pennsylvania Surface Mining Conservation and Reclamation Act of 1971 (P.L.1198)

The 1971 Act applied to both anthracite and bituminous strip mines as of January 1, 1972. The Secretary of Environmental Resources is endowed with the power to issue strip permits, license operators, and control reclamation work.

The Act further stipulates that a bond must be posted when the strip permit is issued to finance reclamation should the operator default in his responsibility. In addition, an acceptable plan for reclamation must be submitted to the Secretary. The reclamation plan desired by the law is to regrade by contouring so that the quality of terrain conditions is maintained. Any variation from the original contour requires a full explanation of the conditions which do not permit backfilling to original contour.

Those mines in the anthracite industry which are stripping thick (25+ feet), steep pitched veins and those which have been active for decades are faced with backfilling spoil totalling millions of tons into pits which are individually up to 700 feet deep. The cost of regrading at this magnitude becomes an economic constraint.

The law does present a definite constraint to anthracite strip mining with its definition of terracing. The maximum angle of 35 degrees allowed at the highwall will be extremely difficult to comply with when the pitches often exceed 45 to 60 degrees. The resulting excavation will not only be costly, but may require removing large acreages of vegetation above the vein. The 35 degree maximum angle will be less hazardous than the existing bottom rocks; however, the environmental costs of disturbing the overburden may not warrant such work.

F.13 Pennsylvania Land and Water Conservation and Reclamation Act of 1968 (Amended 1970)

This Act gives the Commonwealth of Pennsylvania authority to identify and eliminate stream pollution from mine drainage, eliminate air pollution from mine fires, to control underground fires, and to alleviate deep mine subsidence. A $500 million bond for a Land and Water Conservation and Reclamation Fund was established to finance such operations. Whenever it is determined that abatement of mine related pollution is in the public interest, the Act provides for utilizing the Commonwealth's "Eminent Domain Code" and gives access to properties for the purpose of correcting violations of the law. Once lands have been reclaimed a fair market value lien is then placed on the properties.

The constraint to developing further strip mine operations on reclaimed lands would be the effect of the lien raising the price of surface lands to a value which is not practical. Thus, in some regions of the industry, coal reserves near the surface could possibly be lost.

On the other hand, unreclaimed surface mined areas trap precipitation runoff which enters the connecting deep mines, and eventually exits as acid mine drainage. By reclaiming the strip mined areas much of this precipitation would be carried directly to the streams as runoff. The volume of the deep mine pools, once denied their major water sources, should show signs of stabilizing. The problem of dewatering in order to reach the vast deep reserves should then be somewhat less complex and less costly.

Insofar as the Anthracite Region is concerned, substantial funds have been dedicated to reclaim abandoned strip mines, extinguish mine and waste bank fires, and correct subsidence under the 1968 Act.

F.14 Pennsylvania Coal Refuse Disposal Control Act of 1968

The Act establishes that coal refuse disposal piles shall not be operated in such a condition that would create hazards of health and safety to the public. All actively operated banks are to be rendered unsusceptible to sliding, shifting, or burning. Under no condition will a bank be permitted to pollute either air or water.

The Secretary of Environmental Resources has the right to inspect and evaluate the condition of any active bank or parts of any bank being actively worked. He has the authority to order changes of the bank's condition in order to alleviate hazards found.

In cases where deemed necessary by the Secretary and the courts, a refuse bank operator may be given the right to acquire interests or lands for refuse disposal under the Commonwealth's "Eminent Domain Code".

It should be noted that this Act applies only to the actively worked refuse banks or to parts of those banks which are active. The abandoned disposal banks from past mining are not covered under the law.

F.15 Pennsylvania Air Pollution Control Act, 1968 (Amended 1972)

The Air Pollution Control Act gives the Pennsylvania Department of Health powers to investigate and inspect places suspected of contaminating the air; the power to regulate emissions and to place penalties on violations; and the power to develop a comprehensive plan for the control, abatement, and prevention of any new air polluter. The Environmental Quality Board is to have the powers and duties to adopt rules and regulations to prevent and to abate air pollution.

The Act establishes Regional Air Pollution Control Associations and defines their powers. All stationary air contamination sources are required to be licensed and approved by the state. Civil penalties have been established for violations of the Act. The limits for sulphur dioxide stack emissions set by the regulations must be less than 500 ppm by volume.

In 1971, Cornell University published a report "A Critique of the New EPA Emission Standards for New Stationary Sources". The new standard EPA established for coal-fired power plants is 1.2 pounds SO_2 per million BTU's input. By this standard, coal with 0.768 percent sulphur content or less will not require emission controls for SO_2. Anthracite coal usually is determined to have a lesser sulphur content than this amount, thus, with respect to the SO_2 stack emissions problem, anthracite will generally be an acceptable fuel.

CHAPTER III - SUMMARY

MARKETS - PRESENT AND FUTURE

A. TRADITIONAL MARKETS

First uses of anthracite were smelting, distilling, foundries and space heating. Power generation, beneficiating and chemical processes are also important uses. Its advantages include location, high fixed carbon quality, long-continued and smokeless combustion, and lower sulphur content. Some disadvantages are: particulate and ash removal and the higher costs of anthracite utility plants.

Because of these disadvantages and inherent combustion problems, utilities have converted from anthracite to bituminous or oil and natural gas. Since only two firms continue to manufacture custom built traveling grate anthracite stokers, at prohibitively high costs, the installation of less costly bituminous coal burning equipment is encouraged. Solutions must be found to these problems before anthracite can recapture significant portions of the utility market.

If the industry decline continues, it will eventually disappear. However, the world energy situation causes anthracite to be considered a valuable resource. The Consultant's estimates, developed through interviews, result in a total use of about 17 million tons annually by the year 2000. Utilities would be the biggest user. Chemical, iron and steel and coke foundries and processing industries are other important future users. The retail market should stabilize but at a lower level of use. The really volatile end use is the export market which could show considerable growth due to world fuel shortages.

Continuation of today's high prices, well above costs, could, however, have serious long term implications. Too many industrial consumers are discouraged by these high prices and supply interruptions, so some future markets may be lost.

Pennsylvania Power & Light, New York State Electric and Gas and United Gas Improvement Corporation are the only utilities consuming anthracite today. Because of their location and familiarity with anthracite, these firms could be large potential users. New York State Electric and Gas could, in fact, use considerably more anthracite at the present time. Their capacity is 600,000 tons, yet they use only 50,000 tons because of unavailable supplies.

To be competitive in the utility market the long term price of anthracite cannot exceed the delivered price of bituminous plus the cost of sulphur dioxide control. The extra cost of anthracite plants over bituminous must also be considered.

Industrial demands should also be substantial in the future. The chemical, iron and steel, coke, and processing industries are all attracted to anthracite's high carbon content. Some industrial uses are virtually assured markets because of existing processes and the demand for carbon.

The traditional market - home heating - has declined more than any other use. In the immediate Anthracite Region, this market should, however, stabilize, but at less consumption than today.

The export market is presently about 16 percent of current consumption. This end use has excellent potential because of world energy shortages.

B. CONVERSION

A future use that may be triggered by scarcities of natural gas is the conversion of anthracite coal to low-BTU gas. The process already exists, is in use, and widespread adoption could alleviate natural gas dependence for the numerous small and medium sized processing firms in Pennsylvania and the Eastern United States.

Gasification is the partial combustion of carbonaceous fuel so that much of the fuel heat content is retained by the gasses formed and is available for later release when burned in other processes.

The large number of processing industries in Pennsylvania and the location in Pennsylvania of anthracite coal would indicate a potentially substantial demand for anthracite for low-BTU gas generation. With certain adjustments, a low-BTU gasifier can be constructed on-site utilizing the substantial investment in present gas equipment.

It is estimated that curtailments of natural gas may result in the unemployment of some 800,000 workers in the Mid Atlantic Region, not including the interaction of the cost and layoffs in other areas. Conversion to other sources of fuel could also increase the cost to the process industries by three to four times present fuel costs. Thus, rapid adoption and retrofit of fixed bed gasifiers by these industries would have great benefits to government (unemployment costs), industry and the jobless.

There are four types of gasifiers -

Fixed bed
Fluidized bed
Entrained
Immersion (conceptual stage only)

Second generation gasifiers - including most fluidized bed and entrained processes - will not be available commercially until about 1985. Although there is great potential for converting coal to low-BTU gas, present development technology is directed towards advanced low-BTU gasifiers for utilities and high-BTU pipeline gas or substitute natural gas.

The fixed bed process offers an immediate solution because it is available today. Anthracite is high in fixed carbon, produces no chars or tars, and is therefore an ideal fuel for the fixed bed producer of low-BTU industrial gas.

Some commercially available gasifiers are as follows:

- Wellman-Galusha Gasifier developed in the 1940's. This has and could continue to play an ever increasing vital role in the processing industries.

- Riley-Morgan low-BTU Gasifier is another fixed-bed gasifier with less popularity.

- Koppers-Totzek Gasifier is a pressurized entrained process. None are used in the United States but they have potential for anthracite usage.

- Ignifluid Units were developed in 1915. Although technically not a gasifier it could be developed as a gasifier. It can burn coal refuse containing as much as 40 percent ash; hence, there is great potential for use of the vast amounts of coal refuse in the Anthracite Region.

Anthracite coal is adaptable to coal conversion as follows:

1. Fixed-bed gasifier for the process industries, such as brick making, glass making, metals, etc.

2. Ignifluid process using coal refuse material for power generation and, with R & D, gasification for the process industries.

3. Koppers-Totzek unit for production of methanol and power generation.

In general neither industry or government have turned to on-site fixed-bed gas generation. There are two major misconceptions about low-BTU gas:

1. Low-BTU gas at 150 BTU/SCF is greatly inferior to natural gas at 1,000 BTU/SCF. False. It is the combustion gasses that are important. Due to the different amounts of air required to form the combustion gasses the flame temperature of (producer) combustion gas is about 3200 degrees F and that of (natural) combustion gas is about 3800 degrees F. Expressed in another way, the ratio of heat values is about 80 percent.

2. Since existing low-BTU gas producer units produce relatively low hourly outputs, i.e. 25,000,000 to 75,000,000 BTU/hour, they cannot be considered for high volume users. False. If space is not a problem it would seem that cost per BTU produced would be the determining factor rather than the overall size and number of pieces of equipment.

Government could assist as follows:

1. Determine through a study how retrofit can be more expeditiously accomplished by the process industries.

2. Allocate funds for improvements to fixed-bed gasifiers and conduct studies on other types of fixed bed gasifiers which might be more efficient.

3. Assist in studies of the ignifluid process to scale-up this unit, convert it to a gasifier, and to develop a gas generator such as 25 MW for use by small and medium sized industrial users.

4. Broaden the gasification program so that plants developed can use various types of coal and not just high sulphur bituminous coal.

CHAPTER III

MARKETS - PRESENT AND FUTURE

A. TRADITIONAL MARKETS

The first commercial uses of anthracite coal were for melting brass, iron making, distilling, space heating and brick making. Later on anthracite became an important fuel in power generation, metal beneficiating and various chemical processes. In addition to its favorable location near the eastern metropolitan areas, anthracite coal has other advantages. It has a high percentage of fixed carbon, providing long, continued combustion and emiting no smoke. In addition, anthracite's low sulphur quality meets most environmental specifications.

It also has some disadvantages as compared with bituminous coal. For utility combustion, the longer burning time requires that a longer flame path be designed in the boilers. This increases the capital costs of the utility plant. Also in utility use, particulate matter removal is costly and inefficient.

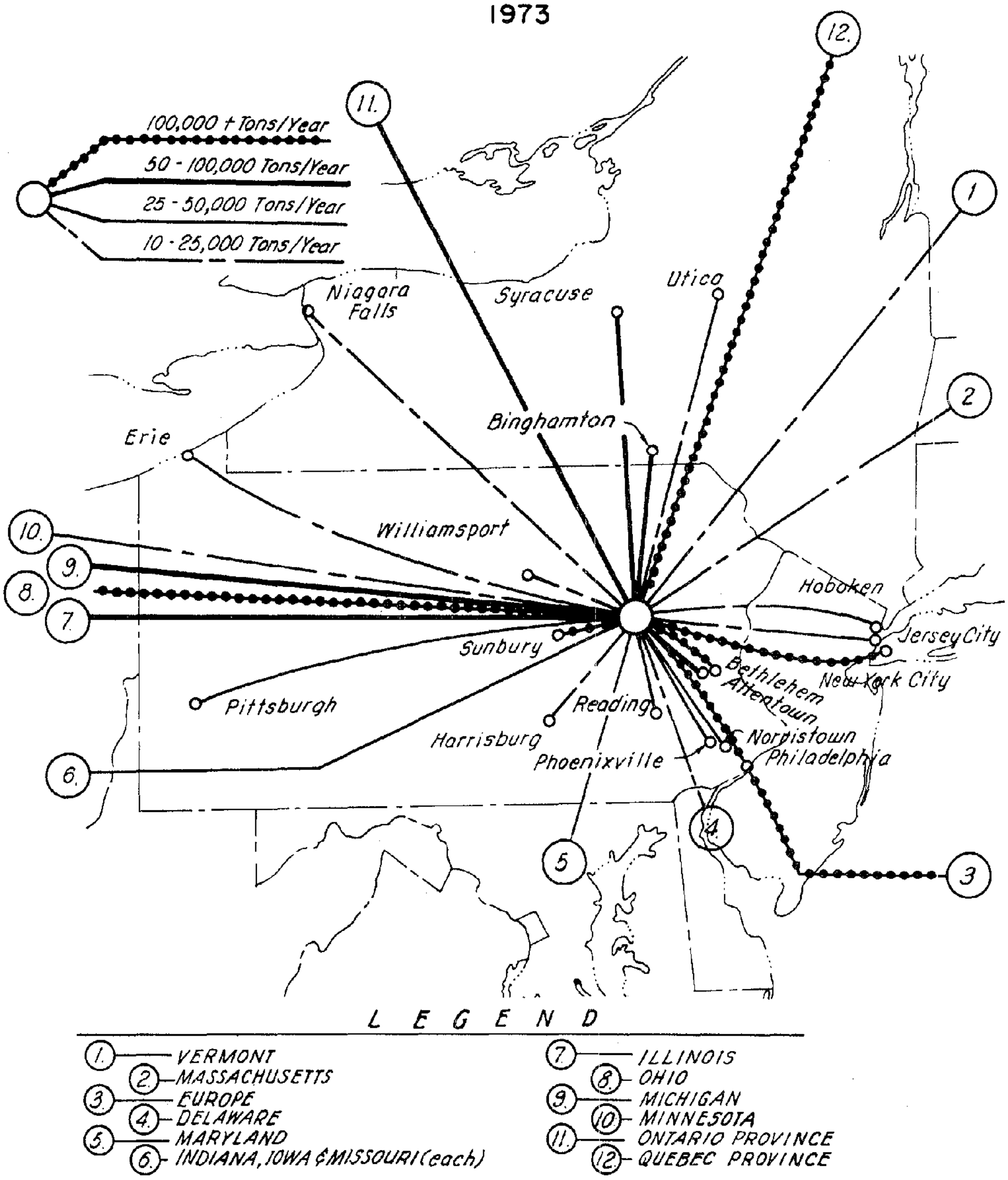
Although anthracite coal in certain geographic areas has a lower BTU cost than either oil or natural gas, it does not share the convenience of the other two fuels because of storage requirements and ash removal. Consequently, its once vast space heating market in the eastern coastal states and Canada has been lost to the oil and natural gas fuels. Its primary destinations today are shown in Plate III-1.

The essential question in evaluating the future of the anthracite industry is the determination as to whether or not markets exist for the resource. Table I-10 dramatically documents the decline of the industry with reference to each of the individual consumer categories. It is apparent that perpetuation of these trends would result, in a relatively short period of time, in the near collapse of the industry. There is, however, evidence to indicate that these trends will not continue, and in fact there is good reason to suggest that the demand for anthracite coal has begun to pick up.

For example, industry officials have repeatedly noted that demand for anthracite has, at least for the past five years, exceeded the available supply by about 20 to 30 percent. Obviously the incentive to expand supply, or perhaps more accurately arrest attrition, has not been sufficient to overcome the risk and uncertainties that have long plagued the industry. The untimely loss, in May 1974, of the Blue Coal Company's operations (1973 production equal to 460,000 tons) aggravated an already difficult supply situation just prior to present excessive price levels.

DESTINATIONS OF TRUCK AND RAIL SHIPMENTS OF ANTHRACITE

UNITED STATES AND EUROPE
1973



SOURCE: Prepared by Consultant based on Data from the Pennsylvania Dept. of Environmental Resources, Monthly Shipments of Anthracite, 1973.

PLATE III - 1

The rapidly deteriorating world energy situation, a phenomena that drastically alters the relative attractiveness of energy resources, is in itself cause to reflect on the future use of anthracite. Whereas the expansion of the anthracite industry was recently considered remote, present day circumstances warrant a full investigation of the potential 17 billion ton domestic energy resource. Therefore, recognizing the uncertainties presently confusing the energy market, we have attempted to identify and analyze potential users of anthracite coal and to estimate their future consumption.

As described in the Preface (and as listed in the Appendix) the estimate of potential anthracite consumption was developed through surveys of present and potential users of the product. Surveys encourage a full review of a potential user's demand limitations, the advantages/disadvantages of the product relative to all of the substitutes and the requisite technological and economic parameters that must be met to improve the attractiveness of the product to a potential consumer. This essentially was achieved through the interviews. The results, we feel, are encouraging for reversing the downward slide of the industry.

A.1 Combustion of Anthracite Coal

No analysis of potential markets is complete without a discussion on the combustion characteristics of anthracite.

During the early development of the steam boiler the production of steam was the paramount concern, without much thought being given to the type of fuel used or the efficiency obtained. During the "hand firing" period of coal burning, anthracite coal was marketed by name and size as described in Chapter II.

The larger sizes of anthracite were used for home and small commercial installations where natural draft was provided by the building's chimney. The coal was fired evenly, in small quantities, and at frequent intervals. The fire was never disturbed with a poker or other firing tool.

The invention of the incandescent lamp resulted in the birth and development of the electric industry. Some of the larger cities built central stations for the generation of electricity using many hand-fired steam boilers of very low output, in pounds per hour, and steam engine driven generators.

As the demand for electricity increased in the early years of the twentieth century, central plants were installing the newly-developed steam turbine for electrical power generation. The development of steam plants of much higher output sometimes required excessive numbers of boilers. This period established that it was not economically feasible or practical to hand fire boilers with steam output above 2000 pounds per hour.

The development of the mechanical stoker to feed coal uniformly onto a grate and to remove ash from the furnace resulted in a high rate of combustion. Larger boilers were designed with greater furnace volume and total output.

The traveling grate stoker was introduced to burn the smaller sizes of low volatile anthracite coal, down to and including Buckwheat No.3 and No.4. This stoker was designed and manufactured in the anthracite coal field.

Many of the anthracite burning-traveling grate stokers are still in service in many industries and state institutions along the east coast of the United States.

Because of the comparatively limited capacity of the anthracite stoker and the increasing size of anthracite boiler units, the users have converted, in more recent years, to pulverized bituminous coal, which is easier to grind and is available in large quantities. Disadvantages of burning bituminous coal are the fines discharged from the boiler stack along with sulphur dioxide and nitrous oxide. Nevertheless, the electrical utilities and the cement industry today use in excess of 40 percent of the total annual consumption of bituminous coal.

The Combustion Engineering Company and the Riley Company are the only firms continuing to manufacture custom built traveling grate anthracite stokers. However, for a new custom built installation, of medium size (below the maximum capabilities of the unit of 400,000 pounds per hour), the cost is prohibitive as compared with the installation of equipment to pulverize and burn bituminous coal. Furnace design for anthracite stoker firing is more costly because of the necessity for the front and rear refractory arches to maintain ignition of the fuel bed, thereby lengthening the residence time.

Costly precipitators and/or "bag houses" are a mandatory part of an anthracite coal burning installation, because of the high rate of fly-ash emission that is an inherent characteristic. Gas and oil firing (except No.6 oil which contains higher sulphur and ash) have little or no pollutants in the exit stack gas.

The advent of the small residential and commercial type anthracite stoker in large numbers between World War I and World War II was a welcome transition to automatic coal firing and a relief from "shoveling" coal. However, the decreasing quality of the coal and the inconvenience of ash removal caused a decline in the home heating market from 80 million tons in 1917 to two million tons in 1973.

Large commercial, institutional and small industrial installations were also confronted with the multiplicity of problems such as federal and state air quality regulations, poor grade of coal, difficulty in procuring required quantities and price. They, too, converted to the cheaper, less pollutant and more convenient gas and oil fuels.

Those electric utilities burning fossil fuels in the anthracite coal region of Pennsylvania are, with noted exception, burning gas, oil or pulverized bituminous coal. The difficulties experienced by several utility companies in pulverizing and firing anthracite coal are not conducive to using the higher priced anthracite coal. The exceptional utilities that are burning anthracite are using the less expensive refuse material.

A.2 Comparison of Fuel Prices

A discussion of fuel prices is also warranted in this Chapter. Anthracite coal prices have normally been higher than bituminous prices because of more costly extraction and processing methods. In addition there is no standard pricing structure for the various sizes of anthracite coal.

Anthracite coal is prepared in various sizes with prices varying relative to the demand and availability of each size. Generally, the larger sizes, such as, egg, stove, and nut are higher priced than the corresponding smaller sizes including rice, buckwheat and barley. Examples of these price variations, per ton f.o.b. mine, were obtained from a coal company and are:

	Egg, Stove and Nut	Pea	Buckwheat and Rice	Barley
1970	$18.00	$16.00	$16.00	$13.25
1972	$17.00	$16.00	$16.00	$13.25
1974	$42.50	$37.50	$37.50	$30.00

The price differential between the large and smaller sizes appears to be based on the availability of sizes from the preparation plant and on the bulk sales of the smaller sizes. Correspondingly, this disparity in prices suggests that the burden of carrying the more expensive anthracite operations is borne by the larger sizes, thus enabling the smaller sizes to compete with other fuels.[1]

It appears that the multitude of anthracite sizes are not necessary for present or future markets. If the industry were to reduce the number of sizes these price differentials would tend to be eliminated and the remaining sizes would more properly reflect extraction and processing costs.

---

[1]George F. Deasy and Phyllis R. Griess, "Fuel Competition in Pennsylvania's Electric Generating Industry", Topographic and Geologic Survey Bulletin M44, Pennsylvania Department of Internal Affairs, 1961, p.34.

The average value of bituminous coal, f.o.b. mine was $6.26 and $7.07 in 1970 and 1972 respectively. These prices are substantially less than those for anthracite as shown in the earlier example. However, in recent years bituminous coal price increases have exceeded the increases in the price of anthracite. The past years' pricing patterns are not necessarily indicative of long term trends, as the world energy shortage radically affected the availability and price of all energy fuels. The relatively larger price increases in bituminous as compared to anthracite improves the competitive position of anthracite coal. It should also be pointed out that the shift away from deep mining and the greater production of lower cost strip coal and culm bank coal dampens the upward increase in the price of anthracite. This trend should continue for the foreseeable future because of the 20 - 30 year availability of strippable anthracite.

In contrast, until this past year anthracite price increases far outdistanced the more stable oil and natural gas fuels. However, the experience during the past year and the expected upward continuation of oil and natural gas prices could significantly alter the relative prices of these fuels as compared to anthracite coal, thus tending to put anthracite in a competitive position once again.

A.3 Results of the Interviews

A.3.a Overall Indications

The outcome of the considerable number of interviews uncovered understandable concern for the future availability of energy fuels, the environmental implication of energy use and the relative economic attractiveness of alternative energy resources. Translated, this concern on the part of potential consumers presages in general a renewed interest, not only in the future use of anthracite coal, but in broader terms a re-evaluation of the users' demand for all energy sources. From the perspective of the anthracite industry this re-evaluation is an encouraging movement, even if a positive outcome is not yet assured. It is worth reiterating, at this point, that the industry faces, and will continue to be faced, with major production and consumption constraints. Some of these constraints will have to be overcome if anthracite is to play a major role as an energy fuel.

Yet, given a substantial growth in anthracite consumption, the incentive to solve these problems will be forthcoming, and a substantial growth in anthracite consumption appears possible. Table III-1, Anthracite Usage, 1974-2000, reproduces the results of the interviews and the Consultant's estimate of potential use. By the end of the century, an estimated 17 million tons of anthracite coal annually could be used. This tonnage is approximately two and one-half times greater than current production. This estimate is considered to be relatively conservative; recognizing in part the massive water problem and other production constraints while at the same time sensing (but unable to fully appreciate at this time) the

TABLE III - 1

ANTHRACITE USAGE IN TONS 1974 — 2000

NO.	COMPANY	COMPANIES' INDICATIONS: PRESENT ANNUAL CONSUMPTION (1974 - 1980) 1974 (APPROX.)	POTENTIAL	USE	POSSIBLE FUTURE ANNUAL CONSUMPTION (1981 - 1990) MINIMUM	MAXIMUM	CONSULTANTS ESTIMATE OF POSSIBLE ANNUAL CONSUMPTION IF COMPETITIVE & TECHNICALLY FEASIBLE (1991 - 2000)	REMARKS
	UTILITIES							
1	Atlantic City Electric Co.	0	0	Electric Power Generation	0	0	0	Combustion Constraint
2	Baltimore Gas & Electric Co.	0	0	Electric Power Generation	0	0	0	Planning & 600 M.W Oil Fired Plants. Would consider Coal if Oil Unavailable
3	Central Hudson Gas & Electric Co.	—	—	Electric Power Generation	—	—	—	No Reply
4	Delmarva Power & Light Co.	0	0	Electric Power Generation	0	0	0	Combustion Constraint
5	Duquesne Light Co.	0	0	Electric Power Generation	0	0	0	Location/ Combustion Constraint
6	Jersey Central Power & Light Co. ①	0	0	Electric Power Generation	0	0	0	Possibility, Although Air Pollution is a Constraint
7	Metropolitan Edison Co. ①	0	0	Electric Power Generation	0	0	1,500,000	Planned Plant Expansion
8	New York State Electric & Gas Co.	50,000	600,000	Electric Power Generation	50,000	3,100,000	2,500,000	If Available - Decision to be made soon
9	Niagara Mohawk Power Co.	0	0	Electric Power Generation	0	0	0	Combustion Constraint
10	Northeast Utilities Service Co.	0	0	Electric Power Generation	0	0	0	Air Pollution Constraint
11	Orange & Rockland Utilities Co.	0	0	Electric Power Generation	0	0	0	Air Pollution Constraint
12	Pennsylvania Electric Co. ①	0	0	Electric Power Generation	0	0	1,000,000	Planned Plant Expansion
13	Pennsylvania Gas & Water Co.	—	—	Electric Power Generation	—	—	—	No Reply
14	Pennsylvania Power & Light Co.	1,000,000	1,000,000	Electric Power Generation	1,000,000	1,000,000	3,000,000	No Plants yet planned, but Possibility if Available
15	Philadelphia Electric Co.	0	0	Electric Power Generation	0	0	1,000,000	Air Pollution is a Possible Constraint
16	Pottsville Gas Co.	0	0	Electric Power Generation	0	0	200,000	If Gasification proves Feasible
17	Public Service Electric & Gas Co.	0	0	Electric Power Generation	0	0	0	Combustion Constraint
18	Rochester Gas & Electric Co.	0	0	Electric Power Generation	0	0	0	Combustion Constraint
19	United Gas Improvement Corporation	330,000	330,000	Electric Power Generation	330,000	330,000	2,000,000	If Gasification proves Feasible
	INDUSTRY							
	Cement:							
1	Coplay Cement Co.	0	72,000	Cement Kilns	72,000	120,000	72,000	Use Bituminous, but can blend up to 50%
2	Hercules Cement Co.	0	0	Cement Kilns	0	0	0	
3	Lehigh Portland Cement Co.	0	0	Cement Kilns	0	0	0	Hardness, Low Volatility and Price are all Constraints
4	Lone Star Industries, Inc.	0	0	Cement Kilns	0	0	0	
5	Medusa Cement Co.	0	0	Cement Kilns	0	0	0	Too Hard for Equipment
	Chemicals:							
1	Allied Chemical Corp.	315,000	315,000	Soda Ash, Foundry Coke	250,000 *	350,000 *	350,000	* Range established by Consultant
2	BSAF Wyandotte Chemicals Co.	70,000	70,000	Soda Ash	70,000	70,000	70,000	Are considering Substitutes
3	Carborundum Co.	—	—		—	—	—	No Reply
4	E.I. DuPont DeNemours & Co.	0	0	Heating	0	0	0	Location Constraint
5	Great Lakes Carbon Co.	350,000	800,000	Foundry Coke, Briquetting and Calcining	1,000,000	1,000,000	1,000,000	10 Year Planned Expansion
6	Hooker Chemical & Plastics Co.	0	100,000	Coke Substitute	100,000	100,000	100,000	Desire Long Term, very low Volatile Anthracite
7	Merck & Co., Inc.	0	50,000	Heating	25,000	50,000	50,000	Would Use, if Available
8	Union Carbide Corp.	100,000	300,000	Cathode Blocks, Electrodes	200,000	500,000	500,000	Can use more, if Competitive with Bituminous Coal
	Iron, Steel & Coke:							
1	Alabama By Products	—	—		—	—	—	No Reply
2	Allen Wood Steel Co.	16,000	16,000	Foundry Coke, Sintering & Blast Furnace	11,000 *	20,000 *	20,000	* Range established by Consultant
3	Bethlehem Steel Corp.	400,000	400,000	Foundry Coke, Sintering & Blast Furnace	400,000	400,000	400,000	Greater Use Possible Owns Greenwood Properties
4	Jones & Laughlin Steel Co.	0	35,000	Foundry Coke	0	35,000	35,000	Two Blast Furnaces. Could use more with four additional Furnaces
5	Lukens Steel Co.	0	0	N/A	0	0	0	No need for Anthracite
6	Phoenix Steel Corp.	—	—		—	—	—	No Reply
7	Eastern Associated Coal - Philadelphia Coke Division	15,000	35,000	Foundry Coke	15,000	35,000	35,000	Expansion unlikely
8	U.S. Steel Corp.	110,000	110,000	Foundry Coke, Sintering & Blast Furnace	110,000	110,000	110,000	Potential for Replacing low Volatile W.Va. Bituminous Coal
	Miscellaneous:							
1	Alcan Aluminum Corp.	20,000	30,000	Aluminum Reduction	30,000	30,000	30,000	Looking for Guaranteed Long Term Supplies
2	Coalcon Corp. (Coal Conversion)	—	—		—	—	—	No Reply
3	FMC Corp.	0	0	N/A	0	0	0	Location Restraint
4	Glen Gery Brick Co.	25,000	63,000	Lo BTU Gas	63,000	63,000	63,000	Additional Wellman-Galusha Gasifiers are Planned
5	Koppers Company, Inc.	35,000	60,000	Foundry Coke	60,000	90,000	90,000	New Plant to use Anthracite
6	New Jersey Zinc Co.	200,000	200,000	Zinc Smelting	200,000	200,000	200,000	Increase with Planned Expansion. Return to Gasification Possible
7	P.H. Glatfelter Co. (Paper)	0	0	Power Generation	0	0	0	Technical Constraint
8	Quebec Iron & Titanium Corp.	350,000	400,000	Titanium Smelting	400,000	800,000	800,000	Expanding Market
	TOTAL REPORTED	3,386,000	4,986,000		4,386,000	8,403,000	15,125,000	
	RETAIL COMMERCIAL, INSTITUTIONAL, HOME HEATING	2,000,000 ②	2,000,000	Heating	1,500,000	2,000,000	1,500,000	Declining Market
	SHIPMENTS ABROAD ③							
	Defense Fuel Supply - Armed Forces, Germany	500,000	500,000	Heating	0	500,000	0	Dependent on Congressional Action
	Exports	280,000	300,000	Miscellaneous	250,000	500,000	500,000	Excellent Potential
	TOTAL	6,166,000	7,786,000		6,136,000	11,403,000	17,125,000	

① Associated with General Public Utilities
② Estimated by Consultant
③ Does not include Shipments to Canada; Canadian purchases in Industry Category

SOURCE: Prepared by Consultant based on Surveys nation's increasing dependence upon domestic fuels and the permanent higher cost of all fuels. The latter two factors could encourage a moderate revitalization of the anthracite industry. Plate III-2 shows the anticipated pattern of growth between the present and 1990.

It must be observed that predictions for growth have not been carried beyond 2000. This limit recognizes not only that projections of over a quarter century are tenuous in virtually every field, but also recognizes that the growth of the nuclear generation of electricity - not to mention other forms of energy generation - could well restrict any further growth in the use of anthracite beyond that date. Where reserves are discussed in other Chapters, the rate of anthracite mining is assumed as a constant 17 million tons beyond 2000.

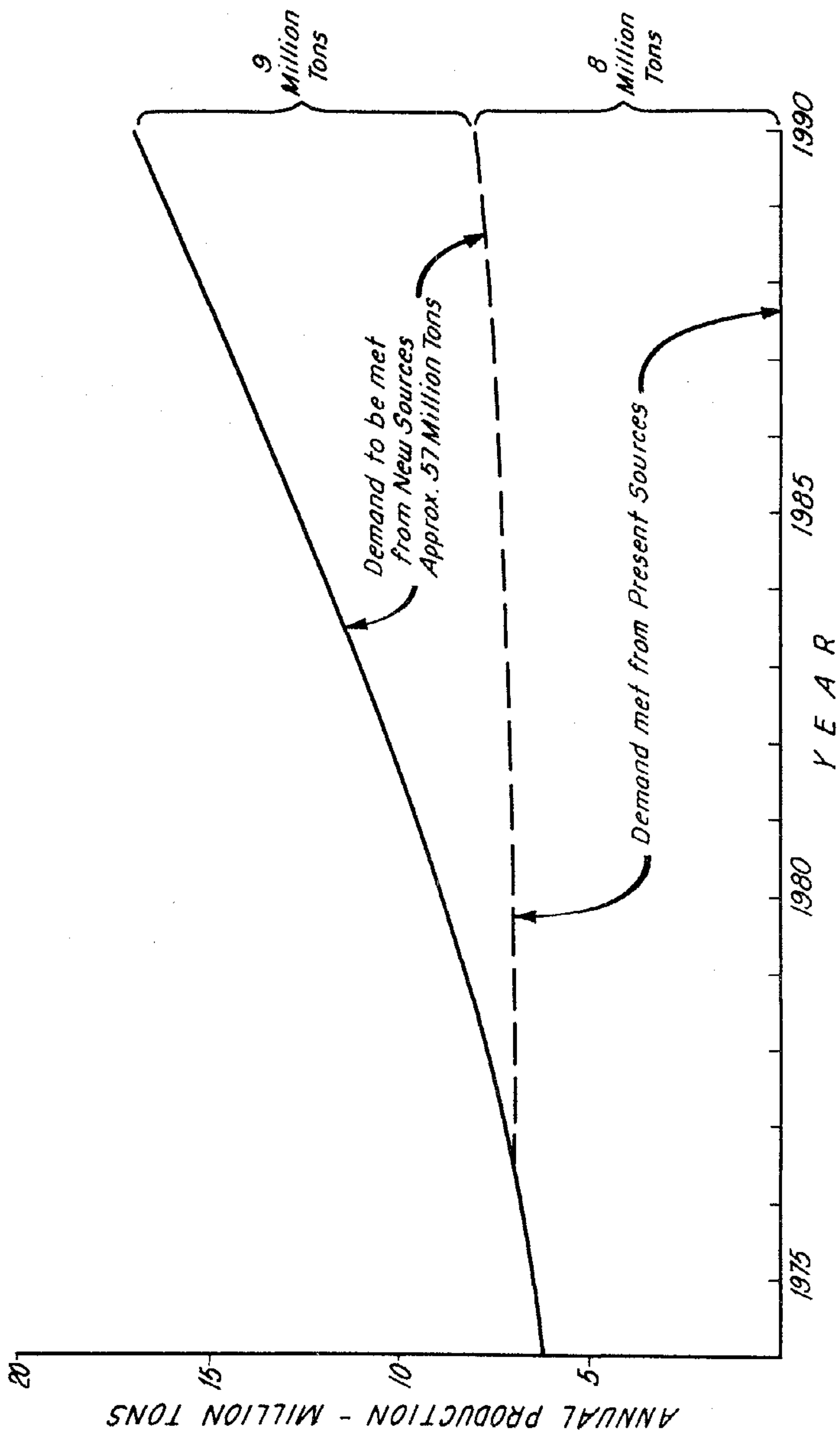
The estimated reserves are more than sufficient to meet the potential consumption, as is discussed in the next Chapter. At the necessary level of production, these reserves can be extracted without resorting to excessively deep mining.

From the interviews it appears that the bulk of expanded anthracite production would be used in power generation. About 66 percent of the year 2000 total estimated consumption is accounted for by the utilities. Industrial use accounts for the next largest demand, with the chemical, the iron, steel and coke, and the non-ferrous metallurgical groups all having significant needs. Because of cost advantages in the immediate Anthracite Region, the retail market, once the mainstay of the industry, will probably stabilize, but at a slightly lower level of consumption.

The export market is extremely volatile in terms of distribution to specific countries, but overall this market has been shown to be stable. It is a good probability that the export market could expand substantially in the next two and a half decades and therefore have a greater impact than at present envisioned. A comparison of estimated and present distributions of anthracite coal are shown in Plate III-3.

The interviews of possible users pointed to two factors which will have particular consequences on the future markets. These are price and assured availability. As noted in the previous section, because of the difficulties associated with the extraction of anthracite coal, the price of anthracite is normally higher than the bituminous price. Current prices for both coals are considerably higher than costs because of the strong demand for coal and the apparent coal shortage. At this time, the anthracite industry should be attempting to offer an attractive price, foregoing the understandable desire to reap excess profits. As is noted in the following text, many current and potential consumers are being forced to look for alternative fuels because the anthracite coal price has been allowed to increase excessively. This situation could have a significant dampening effect on the long term growth for anthracite production as potential consumers seek replacements elsewhere.

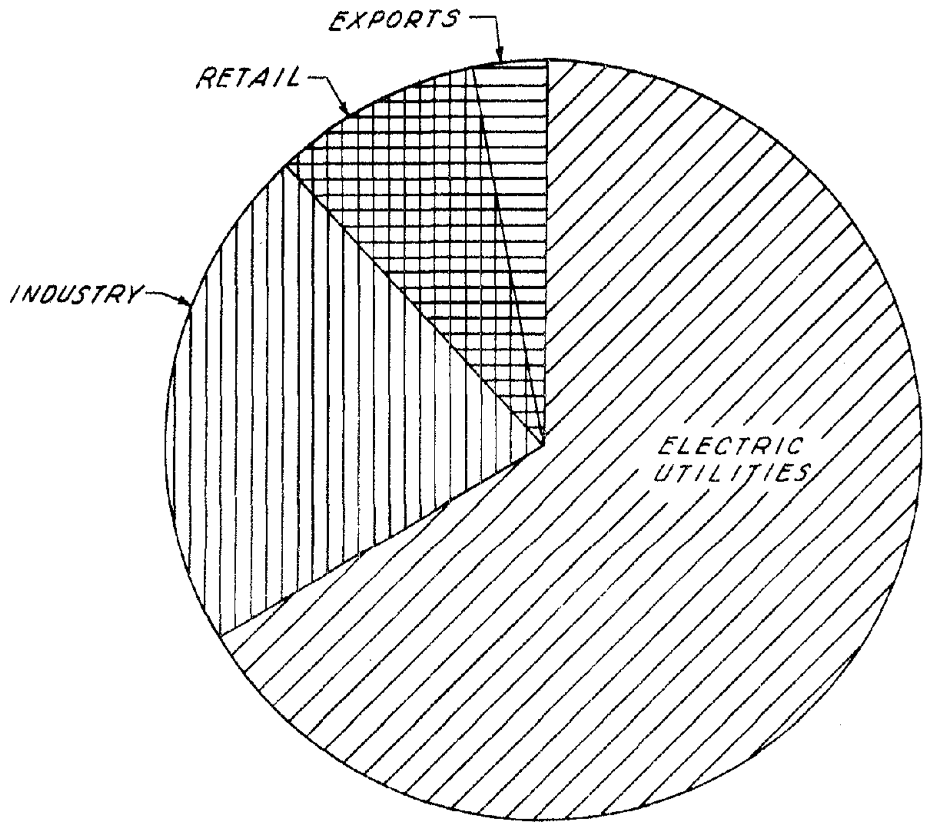
PROJECTED USE OF ANTHRACITE
1974 TO 1990



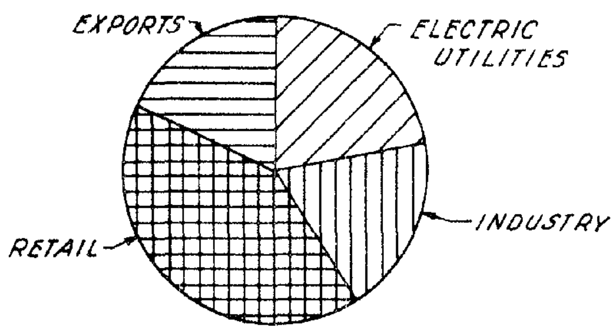
SOURCE: Consultants' Projections

PLATE III - 2

DISTRIBUTION OF ANTHRACITE COAL 1972 AND 1990



1990 (PROJECTED)



1972 (ACTUAL)

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1972 and Consultants' Projections.

PLATE III - 3

Long term available supplies is a particular, but not unique, concern of the utility anthracite consumer. It appears as though the consumer and producer both are desirous of establishing long term contracts. The industry should, therefore, make every effort to develop contractural arrangements but in doing so they must show their ability to maintain reasonable prices. The establishment of long term contracts would reduce the impact on both producers and consumer of rapidly changing spot prices as well as reduce the seasonal and cyclical fluctuations that have negated assurances of financial assistance. Market stability must be established if the industry is to expand.

A.3.b Utilities

Only 15 years have passed since a study conducted for the Topographic and Geologic Survey concluded that "There appears to be little opportunity for Pennsylvania bituminous coal producers to expand their market into the area where low cost anthracite is now entrenched (primarily the Anthracite Region). Such large discrepancies in the delivery cost of the two fuels exist there that a shift to bituminous coal is inconceivable".[1] The inconceivable has occurred in the utility market in the Anthracite Region because the delivered cost of anthracite coal has risen sharply, and because the necessary volumes did not appear to be available.

Today there are three utilities using anthracite coal; Pennsylvania Power & Light Company (P. P. & L.), New York State Electric and Gas Company, and United Gas Improvement Corporation (U.G.I.). All three utilities are consuming anthracite from their own limited-life culm banks, supplemented with Buckwheat No.5 coal. U.G.I.'s anthracite burning plant was built in 1957 to 1959, while the anthracite burning plants of both P. P. & L. and New York State Electric and Gas are their oldest. These conditions, the limited supply of culm and the older generating plants, suggest a further decline in the utilities' use of anthracite sometime in the late 1980's or early 1990's.

However, there is a significant part of the anthracite burning capacity that is being lost to bituminous coal. New York State Electric and Gas, with current combined capacity capable of burning 600,000 tons of anthracite coal annually, is using only 50,000 tons of anthracite coal because of its unavailability. Their near future plans anticipate an additional plant that, if supplies are available, could use considerably more anthracite.

To retain and recapture the utility market, the same factors apply as were presented in the study by the Pierce Management Corporation, that is, consideration of: the relative prices of alternative energy sources, the

[1]Deasy and Griess, op. cit., p.44.

availability of these energy sources for the life of a generating plant, freight rates, and capital and operating costs, including a reasonable return on investment.[1] A more recent addition to this list are the costs associated with meeting environmental standards (additions to capital and operating costs). Finally, a solution must be found to the problems associated with the combustion of anthracite. During the interviews, each of these and other factors were discussed in substantial detail.

In the fall of 1974, coal prices were in the range of $0.60 to $1.10 per million BTU, f.o.b. mine. In this range, anthracite is competitive with bituminous. Also during the fall, oil and natural gas priced close to $2.00 per million BTU. Although these prices are sure to change, and perhaps decline, anthracite can continue to compete geographically as long as the fall in price is not substantial. To be competitive in the utility market, the long run price of anthracite cannot exceed the delivered price of bituminous coal plus the cost of sulphur dioxide control. The additional cost of anthracite plants over bituminous also has to be taken into account. Stated as an algebraic illustration:

$$P_A = P_B + R_B + S_B - C_A$$

Where:

P_A = Price of Anthracite
P_B = Price of Bituminous
R_B = Excess of Bituminous Over Anthracite Freight Rate
S_B = Cost of Sulphur Control in Bituminous Coal
C_A = Excess Cost of Anthracite Boilers over Bituminous Counterparts

Because of their location in or near the anthracite fields, the utilities currently consuming anthracite coal would appear to have the greatest potential demand for anthracite. Further, on the basis of the generating plant expansions planned, or expected to come on line in the 1990's, it is likely that anthracite use could be greatly expanded. Although, as has been indicated to us by various utility companies, electric power growth rates are expected to diminish slightly, additional plant capacity will be needed by the year 2000.

---

[1] "Anthracite Industry Survey, Mining Methods - Research - Preparation", Pierce Management Corporation, Pennsylvania Department of Mines and Mineral Industries, Project No.CR-68, 1967, p.49.

Based on interest expressed during the interviews, their experience with anthracite coal and their location, the following utilities would appear to offer the greatest potential for the future use of anthracite:

New York State Electric and Gas Company
Pennsylvania Power & Light Company
Metropolitan Edison Company
Pennsylvania Electric Company
Philadelphia Electric Company

Two other utilities with locational advantages, United Gas Improvement Corporation and Pottsville Gas Company, would also consider anthracite as an energy source if the gasification process proves feasible. As discussed later in this Chapter, U.G.I. Corporation may use anthracite in the coal to methanol process.

The utility companies, however, would have to be assured of the long term availability of anthracite, at an attractive price, prior to building an anthracite coal-fired boiler. In the past, utility companies have been discouraged from using anthracite coal because of doubts concerning the coal's long-term availability. Since power plants are designed for a specific energy fuel, conversion is both costly and impractical. While limited blending of other fuels is possible, and generally practical, nevertheless, the specified fuel must be supplied for the life of the generating plant. To assure that supplies were adequate both P. P. & L. and U.G.I. designed their present anthracite generating plants to burn culm material which they acquired by purchasing complete culm banks. This material is also considerably cheaper than fresh mined anthracite.

The general response to our questions from utility companies not favoring anthracite was that: anthracite was not compatible with their present equipment because of its hardness and inherently low volatility. The state-of-the art of anthracite coal combustion is not as advanced as bituminous coal combustion.

There are, however, significant advantages to a utility situated in or near the anthracite region in using anthracite coal. Transportation costs, for one, would be minimized or eliminated with a mine mouth operation, and two, anthracite coal is generally at or below the required 0.7 percent sulphur level which would preclude both the capital and operational costs of sulphur dioxide controls generally necessary with the higher sulphur bituminous coal. In other words, the equation on the previous page would tend to favor the use of anthracite coal unless the price of anthracite greatly exceeded the price of bituminous. At present both coals are priced at or near historic highs.

A number of utilities that are now dependent on oil as an energy source, and whose plans call for additional oil-fired capacity, may indeed have cause to reconsider. Although it is obviously very difficult to say with any degree of certainty what the long term price of oil will be, one can presume that oil prices will remain high and at least partially subject to foreign manipulation. If so, coal's attractiveness will be enhanced.

The Energy Supply and Environmental Coordination Act of 1974 further enchances the attractiveness of coal. In essence this law prohibits utilities from burning fuel oil or natural gas if they have the capability to burn coal.

The ultimate question, then, for this particular market remains: Can the anthracite industry assure upwards of 75 million tons per generating unit over a life span of thirty to forty years?

A.3.c Industrial Use

Thomas W. Hunter, Bureau of Mines Industry Economist, in a 1970 study, projected the year 2000 demand for anthracite coal from industrial users at about 2.8 million tons.[1] Our surveys of industrial users now show that this market would approximate 3.8 million tons by the year 2000.

On many occasions the Consultant has been told that the industrial markets, specifically chemicals, steel, and titanium and aluminum processors, are the future of the anthracite industry. Many industrial users are re-examining anthracite in their search for "carbon" in their processes. This may well be the case, but even so it does not appear, from our investigations, that industrial uses alone will "revitalize" the anthracite industry. Nevertheless, the Consultant recognizes that anthracite has the potential for capturing a significantly large share of the 80 million ton per year coke market. This eventuality bears watching as it would, in fact, substantially inflate the industrial use market.

1. Chemical Uses

The industrial carbon market does have excellent long term growth potential. The chemical industry is a stable and essentially a guaranteed market. The high fixed carbon quality of anthracite is generally preferred over coking coal in the soda ash process and in the manufacture of electrodes. Anthracite coal is also used by chemical firms as a blend in the manufacture of foundry coke.

However, anthracite coal operators should not be complacent. With the current confused market condition, the chemical industry has been paying extremely high prices in order to assure supplies of anthracite coal. On occasion, these companies have additionally had to find

[1]Thomas W. Hunter, "Anthracite", Mineral Facts and Problems, U. S. Bureau of Mines, Bulletin 650, 1970, p.30.

their own rail cars for transporting the coal from the breaker to the plant.

More than one chemical firm has expressed concern over the current anthracite price. Wyandotte Chemical, Detroit has been paying around $69 for a ton of delivered anthracite coal. Although they prefer the qualities of Pennsylvania anthracite for the manufacture of soda ash, the high price of anthracite coal has forced them to consider instead the semi-anthracite from Alberta, Canada. The savings to Wyandotte would amount to approximately $10 per ton.

Unless the price of anthracite coal becomes too high, a point perhaps already approached, the chemical industry should remain a strong and steady consumer of this resource. Excessive profits as a short-run expedient would be self-destructive to the industry.

2. Iron, Steel and Coke Uses

The iron, steel and coke industries are another strong and potentially expanding market for the use of anthracite. A favorable indicator of the future use of anthracite coal in this industrial use was exhibited recently with the purchase of the Greenwood Stripping properties by Bethlehem Steel Corporation. This particular anthracite stripping operation is capable of producing a minimum of 400,000 tons per year, with a potential maximum of about 600,000 tons per year. This is the only integrated unit existing in the anthracite industry. In the bituminous industry the "captive mine" is commonplace, and includes companies such as Bethlehem Steel, United States Steel, Pennsylvania Power & Light, and other large coal consumers.

Bethlehem Steel has, and does, use anthracite in sizes ranging from anthrafines to stove size or coarser in their sintering process (their largest use), the manufacture of coke, and as a charge in the blast furnace. The actual distribution of all three of these uses is dependent in any particular point in time on the relative costs of coke and anthracite. Bethlehem Steel consumes approximately the same anthracite tonnage as the current production from the newly acquired property.

Industry officials and users alike are optimistic about the potential of anthracite coal in steel making. The competition for low sulphur bituminous coal among the utilities, foreign users and steel manufacturers has caused a shortage in metallurgical coal. As a result, steel firms have increased their use of anthracite in the coking process.

The steel companies' effort to maintain a high carbon injection in the blast furnace has also expanded the use of anthracite. It appears that the units of carbon in coke have been declining, and therefore the industry is mixing greater proportions of high carbon anthracite coal with the coking coal.

Again, the high fixed carbon quality of anthracite coal, specifically the fines, makes it an attractive fuel for the sintering of ores in the steel industry. Anthracite fines and coke breeze can be interchanged in the sintering process, and their use is dependent upon their relative availability and prices.

Although the steel plants in close proximity to the Anthracite Region offer the greatest potential market for anthracite coals, it is also apparent that there is a potentially significant iron and steel market further removed from the region, despite additional transportation costs. The geographical expansion of this market is, as noted above, due to the shortage of coking coal, and the high fixed carbon qualities of anthracite coal.

However, a further note of caution was expressed in the interviews. The iron and steel and coke consumer faces the same situation as the chemical industry. That is, while they are in the market to consume a greater quantity of anthracite coal, today's prices and anthracite's scarcity are causing these concerns to consider alternatives. A potentially large anthracite-consuming western Pennsylvania steel company has reported that because of "out of line" prices and unreliable deliveries they have ceased using anthracite. This is unfortunate since the expected continued shortage of coking coal provides an excellent opportunity for further anthracite expansion.

3. Cement Uses

Cement plants were, in the recent past, a consistent consumer of anthracite coal. However, today this market has virtually disappeared. The principal disadvantage of using anthracite coal in this market is its hardness which makes it difficult and costly to grind.

Silt or dredge material of about one-quarter inch to dust size has been used by the cement industry with a bituminous mix. Separate storage facilities, however, are required. In some instances it is felt that the cement industry could make more extensive use of silt or dredge anthracite coal, but its use is limited by its higher ash content and the relatively favorable price and availability of bituminous coal.

4. Non-ferrous Metallurgical Uses

Quebec Iron and Titanium Company, Sorrel, Quebec Province, is the largest industrial user of anthracite coal. Beginning in the mid-fifties, consuming about 80,000 tons of anthracite coal annually, their demand has multiplied and in 1975 should be about 400,000 tons. Within the next ten years Quebec Titanium plans to be consuming 800,000 tons annually. Their requirements are: high carbon, low ash and sulphur, and low volatility. These are ideal specifications for anthracite coal. Because of their reduction process, the company is virtually an assured consumer of anthracite coal, and of course, at this time, a very substantial pillar in maintaining the anthracite industry. High prices and supply interruptions are, however, problems for this user as well. They have recently been considering the use of coal from Alberta and South Africa if the price of anthracite continues to rise.

The New Jersey Zinc Company is another large consumer of anthracite coal. As with many of today's users, New Jersey Zinc uses primarily culm bank anthracite mixed with smaller quantities of Buckwheat No.4 or No.5. Their most pressing and immediate concern is with a drastic reduction in their natural gas supplies. The impact from the cutbacks of natural gas may be a further stimulation to the anthracite industry with the availability of the fixed bed gasifier. More is said on this subject in the next section.

In summary, the industrial processing industries, such as copper, zinc, aluminum and titanium reduction are appreciable consumers of anthracite in their various reduction techniques. The market is stable, particularly because such a large majority of anthracite is used by Quebec Iron and Titanium, and is expected to experience additional expansion. Anthracite coal, being a natural source of carbon, is attractive to both the ferrous and non-ferrous metallurgical firms and the chemical industries because of the importance of carbon as an industrial material.

A.3.d <u>Retail - Commercial, Institutional and Home Heating</u>

The retail market has traditionally been the major user of anthracite coal. Anthracite's clean burning and smokeless qualities were once favored by home heaters and commercial establishments alike. Over the years retail use has been faced with stiff competition from the natural gas and oil industry, primarily because of convenience to the consumer. Although this market has experienced the greatest decline, it still remains as today's largest market. However, this is not expected to continue.

The high prices discussed in previous industrial uses have also shaken the confidence of retail consumers. When Blue Coal's production was lost, prices in the retail market in the Northern Field soared to $64.00 per ton. Rapid price increases have, of course, very real social implications, especially as it affects the older segment of the population on fixed incomes.

The retail market should continue to experience further decline, but in the immediate anthracite area, where retail use of anthracite coal is greatest and a cost advantage is obtained over oil and gas, the home heating and commercial market should stabilize. Institutional uses outside the Anthracite Region may, in fact, increase slightly because of air pollution regulations in some of the larger cities and the uncertain future of natural gas and oil supplies.

Federal and State Governments could further stimulate the use of anthracite coal by reversing the movement toward oil and gas, and converting back to coal at the numerous governmental institutions and installations in Pennsylvania. Thus, minimal action on the part of the Government would greatly assist the anthracite industry by stabilizing the allocation of energy fuel and reducing the dependence on energy imports.

A.3.e Exports - Other Than Canada

The export market has been quite stable over the years, hovering around 15 percent of all anthracite consumed. Table III-2 shows the various export destinations for anthracite coal.

It would appear that the export market for anthracite coal has excellent growth possibilities. The Consultant has been informed on numerous occasions of the interest in anthracite coal expressed on the part of potential foreign consumers. This information, which cannot be substantiated or quantified in order to make reasonable estimates, nevertheless indicates favorable conditions for expansion of Pennsylvania anthracite coal in the world market. The effect of the world oil situation calls for a re-evaluation of traditional fuel sources as some countries, particularly Japan, are confronted with economic strangulation. Industrialization of many lesser developed countries, including the capital-rich oil producing countries, means additional demands on all energy fuels. Although world wide supplies of anthracite coal are extensive, a rapidly growing demand could increase the exports of Pennsylvania anthracite to the rest of the world.

The response to a query by the Consultant of future shipments of anthracite coal to selective countries did not elicit any concrete intentions, thus, while appreciating the potential expansion of anthracite exports, the Consultant's estimate shows future demand at about current levels of consumption.

The shipments of anthracite to U. S. military forces, technically not an export, will probably continue at, or near, 500,000 tons annually. These shipments, which were begun by the Congress to stabilize the anthracite industry, would probably be curtailed if anthracite sales on the open market increased appreciably. Therefore, the estimated year 2000 demand does not include shipments to the armed forces.

A.4 Summary of Market Analysis Findings

As a result of the interviews and other sources of information reviewed by the Consultant it is clear that revitalization of the anthracite industry is dependent on the utilities. While the growth prospects of the industrial users of anthracite are anticipated to be favorable, it is the utilities which consume such large quantities of coal that would, if they chose anthracite

TABLE III-2

U. S. EXPORTS OF ANTHRACITE[1]

World
Selected Years 1960-1972

Countries	1960	1965	1970	1971	1972	1973
NORTH AMERICA						
Canada	1,204,414	642,657	438,000	466,039	500,306	477,692
Cuba	25,315					
Mexico	1,879	8,921	5,000	4,316	6,903	8,303
Total	1,231,608	651,578	443,000	470,355	507,209	485,995
SOUTH AMERICA						
Argentina	16	5,084	2,000	4,006	2,721	2,216
Brazil	18,175	2,089	1,000	3,947	3,496	2,475
Chile		397	1,000	905	4,288	4,712
Colombia		429		358	893	512
Paraguay	6					
Peru			6,000			8
Surinam		1,983	1,000	254	263	250
Uruguay	497					
Venezuela	29	9,596	16,000	2,967	13,894	26,796
Total	18,723	19,578	27,000	12,437	25,555	36,969
EUROPE						
Belgium-Luxembourg	10,328	30,816				
Finland				320		532
France	62,362	29,883	229,000	101,330	154,918	105,511
Germany, West		92	8,000	26,248		28
Ireland			2,000			
Italy	53,180	39,093	61,000	229	32,463	28,008
Netherlands	51,830	3,040	1,000	1,469	8	39,221
Spain		29,105				30
Sweden				46	9,240	9,604
United Kingdom		1,277	1,000	22		90
Yugoslavia				33,891	10,987	
Total	177,700	133,506	302,000	163,555	207,616	183,024
ASIA						
India	1,068	5,110	500	278		4,257
Indonesia	31	913				653
Iran				954	55	122
Israel	20	168				
Japan				10,543		
Korea				190		260
Philippines	29	818	1,000	1,042	662	1,213
Saudi Arabia	6					
Singapore				4,149		
Taiwan		2,120				
Viet Nam	11,169	30,185	11,000	2,713		
Total	12,323	39,314	12,500	19,869	717	6,505
AUSTRALIA	46	4,991	4,000	3,976	1,477	2,373
OTHER		1,801	1,000	832	822	1,680
TOTAL	1,440,000	850,630	789,500	671,024	743,396	716,546
U.S.MILITARY Shipments to Europe[2]			692,000	718,000	464,680	436,507
GRAND TOTAL	1,440,000	850,630	1,481,500	1,389,024	1,208,076	1,153,053

[1]Tons

[2]U. S. Military shipment totals include tons consigned to West Germany and the Netherlands. Figures for 1960 and 1965 not available.

Source: 1. Minerals Yearbook, U. S. Bureau of Mines, Selected Years.

2. Mineral Industry Surveys, "Pennsylvania Anthracite Weekly", U. S. Bureau of Mines, March 29, 1974.

coal, result in a viable anthracite industry. Recognizing this, our projections indicate that utilities situated in or close to the Anthracite Region have the potential to consume about eleven million tons per year of anthracite by 1990.

Industrial users are attracted to the high carbon content of anthracite. Consequently, this market is also important to the anthracite industry. Investigations have been conducted to test various fossil fuel blends and agglomerates which could result in greater industrial uses of anthracite. About 22 percent or approximately 3.8 million tons of anthracite is projected for the industrial market, including Canada.

Exports and retail trade projections were based on information collected during the study and indications are favorable for growth in the export market and an eventual lower, but stable, market in the local retail market. Because of the greater uncertainties surrounding projections in either of these markets, these estimates could be significantly altered. However, since these markets are expected to comprise the smallest part of future anthracite use, changes in either direction should not substantially alter the overall estimate of approximately 17 million tons.

An ancillary demand could occur for other minerals found in refuse banks and between coal seams. Germanium, lithium, vanadium, uranium and, most importantly, alumina are all found in refuse banks and there may, as well, be significant tracings of these and other elements between the coal seams. If so, these by-products of the mining and preparation process could prove to be an additional stimulant to the overall extraction of anthracite coal.

A.5 An Old Use Reconsidered - Conversion

The impending natural gas shortage can be crippling to numerous medium and large size processing and manufacturing firms in Pennsylvania alone. New Jersey Zinc, a substantial consumer of natural gas has experienced recent cutbacks in its natural gas allocation, causing the company to consider closing its plant. An alternative supply of gas receiving a lot of attention recently is the manufacture of low-BTU gas from coal.

Manufactured gas is not a new process, in fact this form of gas was extensively used in the early part of this century. Since then there have been a number of improvements made in the gasifying equipment. The Wellman Galusha gasifier is the best known and most widely used.

Widespread use of gasifiers would have a significant impact on the anthracite industry. Since it is too soon to brave a guess on the development of this alternative, it is not included in the Consultant's estimate of future anthracite uses. However, it is recognized that the eventuality of gasification would drastically alter these estimates by extending the industrial market considerably. For this reason, then, the technical feasibility of gasification was considered to be of sufficient value to be included in this report.

B. ANTHRACITE COAL CONVERSION

B.1 General

The subjects of alternative fuels and coal conversion are receiving much attention in the United States, particularly in the northeastern region of the country. This results from many factors, including the recent oil embargo, the consequent rapidly changing cost structures, and the diminishing supplies of proven domestic oil and natural gas.

The natural gas shortage in particular has been developing for quite some time but is now becoming severe. It is estimated that the next five years will see the situation reaching crisis proportions. It is reported[1] that the Mid-Atlantic Federal Regional Council (FRC) ordered a survey of the impact of gas curtailments to interruptible customers by its Economic Dislocation Task Force. They stated:

> In many cases where blast furnaces, refractories or other industries which use gas in the processing of raw materials, the effect was expected to result in direct layoffs depending on the percentage of gas withheld. In many cases, the conversion to other sources of fuel could increase cost by three to four times. Just the impact on half the known employment would have tremendous repercussions on the region. The potential weighted reaction could reach some 800,000 employees. This does not take into account the interaction of the cost and layoffs in other areas.

In Pennsylvania alone, gas utilities have imposed a 45 percent cutback on industrial users, and statewide there is a total estimated 20 percent cutback. Loss of jobs in the state is estimated at 15,000 in the industries involved with another 30,000 indirect losses, according to the Governor's Energy Council. The situation is so critical that the Governor has proclaimed a "natural gas emergency" in the State of Pennsylvania.

In the Anthracite Region, one utility company increased its cut-backs in natural gas supplies to 58 percent for 33 big industrial customers.[2] The lack of a Federal Energy Policy is involved here also, but with the Federal Government moving towards greater dependence on domestic coal and less on foreign oil and gas, the problem of the process industries must be faced squarely.

---

[1]Weekly Energy Report, Special Issue, February 4, 1975.

[2]Wall Street Journal, January 21, 1975.

Pennsylvania's energy distribution is: coal 39 percent, natural gas and oil two percent, and imports from other states and overseas 59 percent. This wealth of coal is either high in sulphur or high in ash, therefore, in most uses there is a need to convert it to a clean fuel to burn without environmental problems.

The subject of anthracite coal conversion, both past and present, mainly concerns the gasification of anthracite. In general, gasification is the partial combustion of carbonaceous fuel to the extent that much of the fuel heat content remains in the gases to be released when the gases are later burned by other processes. Gasification essentially includes in the process coal, oxygen (in the form of air or oxygen) and steam.

At the present time no one is seriously considering the use of anthracite in the coal liquefaction process (solvent conversion of solid to liquid form), due to certain properties of anthracite in which other solid fuels are better suited. An exception might be the coal to methanol (a liquid) process. However, as discussed later, this is really a gasification process in which the low-BTU gas formed, called Syn-gas, is converted in a second step to methanol.

B.2 History of Gasification

The gasification of anthracite is not a new subject, but dates back to the latter part of the last century. In this period it was very common to convert anthracite to a low-BTU gas known as producer gas or town gas. This gas had a heat value of approximately 540 BTU/SCF.[1] It was common to use this gas at process industries and it was the main source of gas for gas utility companies in the eastern United States. These central plants have now been largely phased out, starting in the 1950's with the advent of apparently abundant natural gas (pipeline gas).

B.3 Gasification and the Process Industries

It would appear that anthracite coal gasification can once again play a vital part in the energy problems facing the process industries of the northeastern United States. It is reported that Pennsylvania, for example, has more process industries than any other state in the union. Many of these medium to smaller size industries are faced with past or imminent curtailments of natural gas. Mr. Paul S. Lewis, Research Scientist, Energy

---

[1]British Thermal Units per Standard Cubic Foot.

Research and Development Administration, Morgantown Energy Research Center, Morgantown, West Virginia, recently stated,[1]

> Near term (through 1985) prospects for reviving a substantial demand for anthracite largely will be dependent upon a return to on-site gas generation. In former years many industries, such as metal and glass, generated their own gas from coal or coke. Today large natural gas consumers are planning construction of gas generators in order to insure their future gas supply. Anthracite fields, being favorably situated with respect to the industrial eastern states, again could be a major source of fuel for gas generation.

Collectively and individually there is a very substantial investment by these process industries in their present natural gas combustion facilities. In converting to coal they cannot economically demolish these natural gas facilities and replace them with coal burning equipment. A low-BTU gasifier can be constructed at these plants and, with certain adjustments, the plant can continue to operate. Boilers, for example, would have to be derated. Uses might include direct-fired process use, heat or steam raising.

B.4 Types of Gasifiers

The subject of coal gasification is receiving much attention and developmental funding in this country. Mr. Erle K. Diehl, Bituminous Coal Research, Monroeville, Pennsylvania stated at the 1974 Coal and The Environment Technical Conference, Louisville, Kentucky, that BCR had made a survey in 1965 under contract to the Office of Coal Research which identified 65 separate coal gasification processes.[2] These processes were, at that time, either commercial, under active development, or conceptual. Since that survey several new processes have emerged. These gasifiers fall into four groups, fixed-bed, fluidized bed, entrained, and immersion:

1. The fixed-bed process operates with the fuel bed supported from below by a grate or similar device.

2. In the fluidized bed process gases flow upward through a bed of particles with sufficient velocity to support their weight, but not carry them out of the bed.

---

[1]Anthracite Research Conference, University of Scranton, Scranton, Pennsylvania, January 6, 7, 1975.

[2]Paper entitled "Gas Generator Update".

3. In the entrained gasification process (sometimes also known as suspension) pulverized coal is suspended in the gasifying medium and the mixture passes through the gasifier along a high to low temperature profile.

4. With immersion gasifiers the fuel is introduced below the surface of a molten pool of metal or metal salts. These units are only in the conceptual stage.

In general, it is not expected that the second generation gasifiers will be commercially available for gas generation until about 1985. These include most of the fluidized bed and entrained gasifiers - those working on a pressurized principle and usually an oxygen feed. These units require pulverized coal and favor the use of high volatile fuels. One of the encouraging aspects of this urgent research is that it is possible to remove the sulphur in the burning stage - thus overcoming a major problem with bituminous coals in most other forms of combustion. This, of course, is not an important consideration with low sulphur anthracite coal.

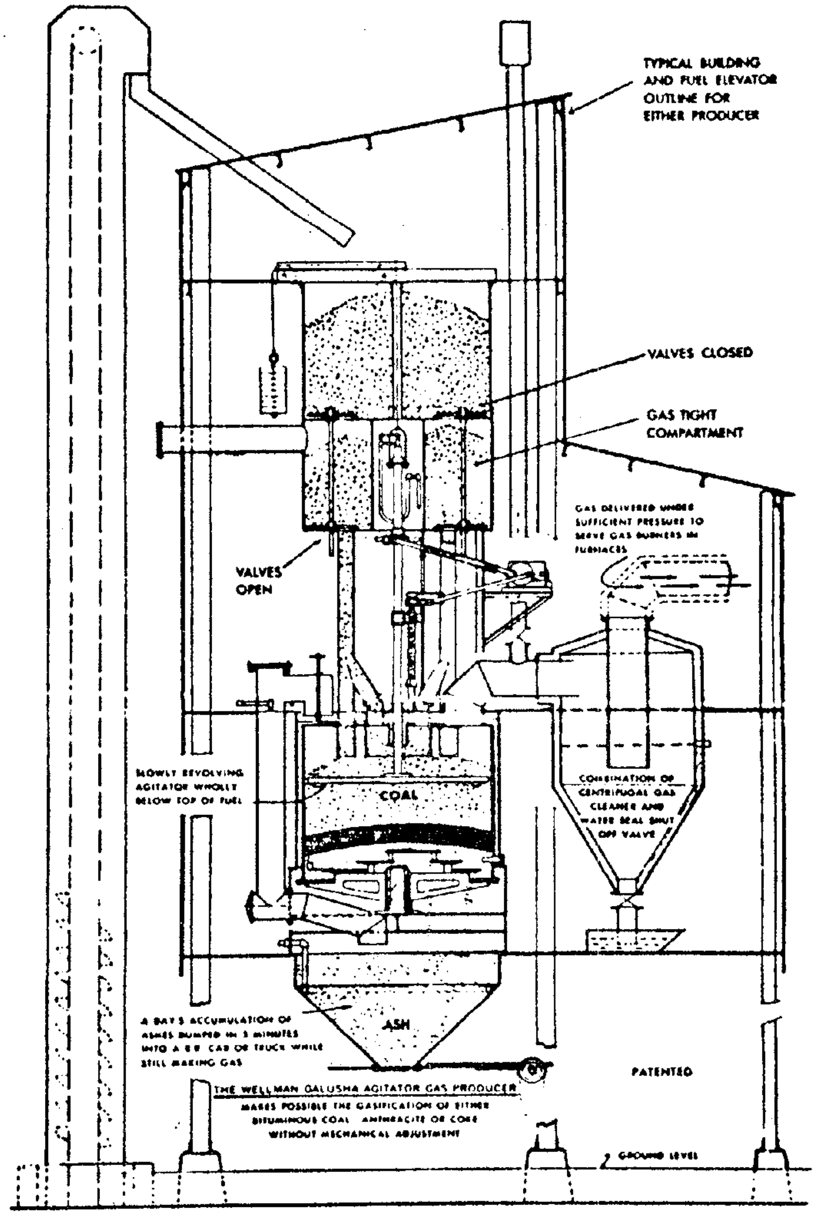
Such research is of little comfort to the industrial manager or owners looking for a "near term" or immediate solution to his natural gas curtailment problems. Converting to other fuels could increase costs three to four times. Unfortunately, almost all of the present developmental technology for coal gasification is directed towards low-BTU gas for use by utilities and high-BTU pipeline gas, or substitute natural gas (SNG). Because the subject of low-BTU on-site coal to gas production is an old one, this does not necessarily mean that it is not a valid concept, or that it does not have a place in the total energy picture. It is recognized that low-BTU gas cannot be transported through pipelines due to the economics of the situation, but it can be valuable through on-site gas generation. Some smaller governmental funding for fixed-bed low-BTU gasification could greatly assist in solving the present problems of the process industries. The technology for fixed-bed gasifiers is old and proven. However, some assistance to the process industries on how to expeditiously convert to use of a producer is needed, along with gasifier improvements. Fortunately there are a number of fixed-bed gasifiers available on the market today.

Some of the existing and proposed gasifiers include:

B.4.a Wellman-Galusha Low-BTU Gasifier (Fixed-Bed)

Some fixed-bed gasifiers are commercially available today in this country, having been developed in the 1940's. (The Lurgi fixed-bed gasifier was developed in Europe in the 1930's). The most common one is the Wellman-Galusha unit manufactured by McDowell-Wellman Engineering Company of Cleveland, Ohio. These units are very common in Europe, the most active supplier being Wellman-Incandescent of England.

WELLMAN-GALUSHA AGITATOR TYPE GAS PRODUCER



HOT RAW GAS

PLATE III - 4

In this country, with the switch to oil and natural gas, most of the Wellman-Galusha's were already dismantled or in the process of being dismantled when the current energy situation clearly emerged. An example is the Glen-Gery Corporation, manufacturers of brick in Pennsylvania and Ohio. This company had dismantled all their gasifiers except four. Two units were placed back on-line when the company, like many others, was faced with successive curtailments of natural gas. The other two units are on standby. The company is pleased with the units and is in the process of adding a new one which will make a total of five. These units, along with the brick kilns, operate 24 hours a day. It is these companies, such as glass making, brick making, metals, etc. where the fixed-bed gasifier can play a vital role.

Glen-Gery Corporation has been experimenting with the use of high ash anthracite culm material. However, they report that the tests have not been very successful. Similar tests were performed by the Anthracite Experiment Station, U. S. Bureau of Mines, Schuylkill Haven, Pennsylvania, in the early 1950's.[1] They also found in using a Wellman-Galusha Producer that a large number of fines did not perform very satisfactorily. More recently, Glen-Gery has been looking into the economics of briquetting. However, the briquettes must have considerable strength to operate satisfactorily.

Should the price of anthracite continue to rise the use of bituminous coal would become more attractive, especially if economical gas scrubbing can be achieved and the operating problems with char overcome. The anthracite coal industry could lose many potential and existing markets in this manner.

B.4.b Riley-Morgan Low-BTU Gasifier (Fixed-Bed)

Another fixed-bed gasifier is the Riley-Morgan. This unit has seals at top and bottom - the lower seal being a water seal. It is a less popular gasifier, probably because of its use of seals, which are a prime source of maintenance in gasifiers.

B.4.c Fixed-Bed Gasifier Experimentation

The Energy Research and Development Administration currently is experimenting with a modified Wellman-Galusha at their Morgantown Research Center, Morgantown, West Virgina. This unit produces 150 BTU/SCF, and is a medium pressure stirred fixed-bed gasifier using air and steam. Also, the Pennsylvania State University, in conjunction with the Pennsylvania Science and Engineering Foundation, proposes to construct a unit for experimentation on

---

[1] J. W. Eckerd, J. D. Glendenin, W. S. Sanner, and R. E. Morgan, Gasification of Bone Anthracite, U. S. Bureau of Mines, RI 5594, 1960.

the main campus. However, it is understood that the latter project is held up for lack of additional funding. Finally, the Hazleton, Pennsylvania CAN-DO Industrial Park, with the assistance of the Appalachian Regional Commission, is studying the feasibility of constructing Wellman-Galusha gasifiers to serve a group of industries in the Industrial Park.

Fixed-bed gasifiers operate on either anthracite, bituminous, or coke. However, anthracite is attractive for fuel and has ideal characteristics since it is high in fixed carbon, is low volatile and produces no chars. Char is not a problem when operating with anthracite, an important point in the maintenance of gasifiers. It is reported that Wellman-Galushas are very dependable and require few operating personnel - factors attractive to industry. Only one man is required for part of the day to operate a producer. Yearly maintenance involves about 200 man-hours for shut-down, inspection and repairs. A mixture of the three smaller sizes of coal (pea, rice and buckwheat) is desirable for a fixed-bed gasifier. At capacity the larger size ten foot diameter producer uses 25,000 tons/year of anthracite coal. One day's accumulation of 20 tons of ash is discharged to a truck in five minutes.

B.4.d Koppers-Totzek Gasifier (Entrained)

Another commercially available gasifier which can burn anthracite as well as bituminous coal is the Koppers-Totzek. This is a pressurized entrained gasifier. Like the Ignifluid and the Lurgi units, it suffers from the fact that no Koppers-Totzek gasifier exists in this country. United Gas Improvement Corporation (UGI) of Wilkes-Barre, Pennsylvania, operating electric and gas properties in eastern Pennsylvania, is a utility company which made extensive studies based on the Koppers-Totzek gasifier. UGI made studies of a pilot plant using this gasifier to produce Syn gas which is a basic chemical easily converted to methanol. Methanol is easily transported, handled, and stored. It is a liquid which can supplement supplies of gasoline (as an extender), natural gas (by conversion), fuel oil, etc., including a substantial use for chemical grade methanol in industry. It would appear that this coal/methanol process is quite feasible and no additional R&D is required for practical application. It is presently made from natural gas which is itself in short supply. This natural gas could be released for other uses if anthracite were used. A full scale plant would cost approximately $350 million, and produce 500,000,000 gallons of methanol annually from 3,000,000 tons per year of coal. The return on investment for this expenditure must not be dependent on the vagaries of foreign oil and natural gas (LNG) prices. It is reported that UGI's plant is held up pending a national energy policy which would supply the above assurances.

B.4.e Ignifluid Units

Ignifluid units (another anthracite burning unit which has received much attention in Europe) also deserve consideration, but at the present time are not strictly gasifiers. They have yet to be introduced in this country, although they have many unique features. Some 35 commerical Ignifluid units are on-stream in Europe and northern Africa. Original developer in 1915 was a Frenchman, the late Mr. Albert Codel. The patents are now held by Babcock-Atlantique. The largest installation to date is a 60 mw boiler plant in Morocco which has a normal operating capacity of approximately 55 mw. This Ignifluid (fluidized bed) unit can burn anthracite, bituminous and coal refuse containing at least 40 percent ash. The moving grate is inclined at an angle of ten to twelve degrees with the bottom ash agglomerating and discharging over the high end. Grate size is only about 15 percent that of a standard anthracite spreader stoker. Primary air (50± percent) is introduced up through the grate at such a velocity that the coal literally is suspended in mid-air along a nearly horizontal line above the grate. Secondary air (50± percent) is introduced above the grate to complete the combustion process. The fluidized bed is reported to look like a gas furnace with an intense incandescent white heat. The efficiency is reported to be as high as with pulverized firing. It produces no fly ash as all of the dust from the precipitators is reinjected back into the furnace. Therefore, there is no need for fly ash ponds. Electrostatic precipitation is very successful as the fly ash of an Ignifluid boiler is high in carbon and, therefore, low in resistivity (opposite to pulverized coal boilers in the United States). All ash is, therefore, bottom ash in the form of an agglomerate which can be used for making block, etc.

The possible application to the 800 to 900 anthracite refuse banks in the region are obvious. Again, UGI made extensive studies of this unit for power generation. However, modern utility plants now are of such size that the application to large utility plants apparently loses out in the "economies of scale". Pennsylvania Power and Light Company, for example, now has a policy of building no new units smaller than 800 megawatts. UGI compromised in their study to suggest an Ignifluid plant of 125 mw. Even with a scale-up to larger units for just a 125 mw plant quite a few such units would be required. Therefore, initial capital costs would be high. UGI tests of Pennsylvania anthracite culm conducted in Europe and Africa indicated that carbon in the ash would be approximately 17 to 20 percent, rather than the four to eight percent experienced by the overseas anthracite. However, it was felt that this could be reduced to less than ten percent by adding a post-combustion furnace similar to the type used for expanded ash for lightweight aggregate purposes.

The efficiency of the Ignifluid unit, even using low grade fuel, is such that it should have a part to play, perhaps again with the medium to smaller size process industries. Experts have said that it could probably be easily converted to a gasifier.

B.5 <u>In Situ Gasification</u>

To the best of our knowledge in-situ gasification has not been tried in the Anthracite Region on a test basis.

A Battelle Energy Program Report[1] describes the method as follows:

> In situ gasification, also called underground gasification, is a process for gasifying coal by ignition of the coal in place in the presence of air, oxygen, steam-air, or steam-oxygen mixtures. Means must be provided for admission of the gasifying agent and for withdrawal of product gases. This may be accomplished via shafts and tunnels or by means of boreholes. The process permits recovery of a portion of the energy in the coal without recourse to mining methods to remove the coal from the deposit in which it occurs.

The method may have considerable advantages over above ground gasification, including that of cost. However, in most studies to date the gas has been generally of poor quality. It is difficult to achieve the same degree of control as with a surface gasifier.

B.6 Economic Feasibility of Anthracite Coal Conversion

In summary, it would appear that anthracite coal has many benefits and is adaptable to coal conversion as follows:

1. Fixed bed gasifier for the process industries, such as brick making, glass making, metals, etc.

2. Ignifluid process using coal refuse material for power generation, and with R&D - gasification for the process industries.

3. Koppers-Totzek unit for production of methanol and power generation.

Anthracite coal is an ideal fuel because it produces no chars or tars, is low in sulphur and with reasonable prices of anthracite yields low operating costs when used in fixed-bed and some other gasifiers.

The eventual effect of the gasification of western coals and other bituminous coals is unknown at this time. Two pipeline companies are starting projects using Lurgi gasifiers and New Mexico coal. Other plants employing the Lurgi process are contemplated using western coal. (The Lurgi, a high pressure fixed-bed gasifier, and the Winkler, a fluidized bed gasifier, are also commercially available at this time). It is understood that the biggest problem facing the construction of the plants using New Mexico coal is the problem of raising the required capital. One must question at what economic rate these western coals will be synthesized into a high-BTU gas to be pipelined into the northeastern United States. There are also a number of

[1] Liquefaction and Chemical Refining of Coal, Battelle Columbus Laboratories, July, 1974.

studies and pilot plants leading to the eventual construction of large scale low-BTU gas generators using high sulphur coal for use by combined cycle gas turbine-steam power plants.

If a number of process industries install their own on-site gas generators, history could repeat itself in that pipeline gas could again make such generators uneconomical. It is difficult to place estimates on the possibility of this happening due to the rapidly changing cost picture in various types of fuels and the unknowns in fuel conversion. However, at the Morgantown Research Center it has been broadly estimated that low-BTU gas can be produced for $1.75 per million BTU's.

While the technology undoubtedly will be developed for second generation gasifiers in perhaps ten years, it is known that there are quite a few problems, not to mention considerable capital and operating costs, with large scale fluidized/entrained bed gasifiers. It is estimated that high-BTU coal gasification processes will cost at least $2.00 to $2.50 per million BTU. Others have estimated a rate as high as $4.00 per million BTU. If technology does not produce this synthetic gas at a cost that is competitive with other fuel sources, it is possible that it would be governmentally subsidized to carry out national goals.

Mr. Paul S. Lewis of the Morgantown Research Center has stated that some of the problems with the advanced generation gasifiers are:

1. Carbon utilization.
2. Maintaining seals in high pressure fluidized or entrained beds.
3. Getting molten slag out of a pressure vessel.
4. Maintaining the walls with the corrosive slag.
5. Development of cracks in the refractory brick, a serious problem in a pressure vessel.
6. The treatment of the waste produced.

Mr. Lewis categorized these second and third generation gasifiers into two categories:

1. Experimental gasifiers
    a. HYGAS (fluidized bed)
    b. CO_2 ACCEPTOR (fluidized bed)
    c. BI-GAS (fluidized bed)
    d. SYNTHANE (fluidized bed)
2. Conceptual Gasifiers
    a. Molten Salt (immersion)
    b. Molten Iron (Immersion)
    c. Ash Agglomeration (fluidized bed)

On the other hand, the cost of a Wellman-Galusha fixed-bed gasifier is estimated at approximately $200,000. It is also estimated that approximately another $175,000 to $200,000 is required for installation. This would include some site work, a suitable building to house the unit, and auxiliary equipment. There are some problems in converting over to low-BTU gas; however, the Glen-Gery Corporation experience shows that these are not insurmountable and the proper adjustments can be made.

In this regard Government can assist the process industries, etc. by determining, through a study, how retrofit can be more easily done. There is also a need for governmental funds to assist in developing improvements to fixed-bed gasifiers and to conduct studies on other types of fixed-bed gasifiers which might be more efficient. There is a need for further studies of the Ignifluid process to scale-up this unit, convert it to a gasifier, and to develop a gas generator such as 25 mw, which can be used by small and medium size industrial users. Finally, gasification development should be broadened so that the plants developed can use various types of coal and not just high sulphur bituminous coal.

It must also be said that, except for a few instances, industry has not recognized or turned to on-site fixed-bed gas generation. Governmental representatives could encourage this. (Industries are currently turning to SNG, costing $4.00 to $5.00 per million BTU).

One major misconception that industry holds is the alleged inferiority of low-BTU gas - 150 BTU/SCF vs. 1,000 BTU/SCF. It is the combustion gas that is important. Air and low-BTU producer gas are mixed at a ratio of nearly 1 : 1, while air and natural gas are mixed at a ratio of approximately 10 : 1. The result is that equal amounts of combustion gasses from a producer and natural gas have a ratio of about 80 percent heat value. Flame temperature of (natural) combustion gas is about 3800 degrees F. and that of (producer) combustion gas about 3200 degrees F.

Another misconception about low-BTU gas is that since existing low-BTU gas producer units produce relatively low hourly outputs, i.e. 25,000,000 to 75,000,000 BTU/hour, they cannot be considered for high volume users. If space is not a problem it would seem that cost per BTU produced would be the determining factor rather than the overall size and number of pieces of equipment.

Another point that is overlooked is that, using low sulphur anthracite, the hot combustion gas from a fixed-bed gasifier can usually be used directly by a process industry. In the case of high sulphur bituminous coal there is a certain loss of efficiency through the gas cleanup phase since the producer gas must be cooled down during the sulphur removal process. Obviously there is also an additional capital cost, when using bituminous coal, in providing the scrubber equipment.

In summary, coal conversion by gasification can be an increasing market for anthracite coal. However, the large federal developmental program for second and third generation gasifiers does not include anthracite. It should.

CHAPTER IV - SUMMARY

ANTHRACITE RESOURCES

All of the bedrock formations of the area are sedimentary in origin and are primarily sandstones. The Llewellyn and Pottsville are the principle coal bearing formations.

The coal basins are formed by synclines and anticlines which have been intensely folded and contorted and contain numerous faults. As a result of this faulting the pitch of the beds varies from being horizontal to vertical and in some areas the beds are overturned.

The data available on the resources of all the fields in not accessible on a uniform basis. The last detailed estimate of the reserves was completed in 1945 and an update of this data was published in 1972. A great deal of time was spent in this study to tabulate the resources of the Southern and Western Middle fields by U.S.G.S. quadrangle location and depth. It was not possible to catalog the resources of the Northern and Eastern Middle fields in this fashion because of the lack of recent geologic cross sections.

It is estimated that the combined resources of the four fields is 17,418,000,000 net tons, and is subdivided as follows:

Northern	1,944,000,000
Eastern Middle	275,000,000
Western Middle	3,048,000,000
Southern	12,151,000,000

The strippable resources are estimated to total 993 million tons, with the individual fields containing the following amounts:

Northern	405,000,000
Eastern Middle	43,000,000
Western Middle	215,000,000
Southern	330,000,000

There are more than 910 million cubic yards of anthracite refuse. The various classifications of refuse contain between 15 and 25 percent salable coal or a total of approximately 120 million tons. The total tonnages of coal from refuse in the individual fields are:

Northern	47,000,000
Eastern Middle	12,000,000
Western Middle	49,000,000
Southern	12,000,000

An estimate of the coal available with the following physical and chemical properties has been made: heat value, ash content, grindability, percentage of volatile material, sulphur content and percentage of fixed carbon.

Present data shows that there are at least 167 known mine pools and that the cessation of operations in the Northern field has resulted in the formation of one more or less continuous pool. It is estimated that the volume of water contained in the various fields is as follows:

Northern	262,000,000,000 gallons
Eastern Middle	14,000,000,000 gallons
Western Middle	61,000,000,000 gallons
Southern	38,000,000,000 gallons

In addition to the drawdown of the static pools, infiltrating water will also have to be pumped to the surface and treated. An estimate of the amount of water which would seep into the various fields is summarized below:

Field	Seepage
Northern	58,000,000,000 gallons
Eastern Middle	15,000,000,000 gallons
Western Middle	37,000,000,000 gallons
Southern	73,000,000,000 gallons

The cost to lower and maintain the pools at depressed levels has been estimated for each field in addition to the cost to remove the water which infiltrates continuously into the mines. The costs computed are in dollars per month and are based on the continuous operation of the pumps in order to lower the main pools by each increment of 500 feet in a period of a year.

SUMMARY OF DEWATERING COSTS

Static Pool	Northern	Eastern Middle	Western Middle	Southern
VF-500	$152,000	$12,000	$65,000	$ 28,000
500-1,000	360,000	4,000	57,000	54,000
1,000-1,500	150,000		7,000	25,000
1,500-2,000				16,000
Infiltration	$ 69,000	$ 7,000	$53,000	$109,000

Prior to discharging any water into the streams it will have to be treated. Assuming a hydrated lime system would be used, the capital and operating costs would be approximately $0.30 per 1,000 gallons of water treated.

The anthracite resource availability in the Northern field and the Eastern Middle field, although representing a sizeable and meaningful fuel source, does present significant extractive problems because of voluminous impoundments and urbanization. The Northern field in particular contains the largest concentration of recoverable refuse material and must be considered as a viable energy source.

A perusal of the tabulation of resources available indicates there are several areas which could provide for the demand through the year 2,000. An example area is a portion of the Minersville Synclinorium. Concentrated mining in limited areas such as this would reduce the pumping and preparation costs. The estimate for dewatering the previously mentioned area is summarized below:

Depth	Cost to Lower Static Pool	Infiltration	Total
VF-500	$ 8,000/month	$16,000/month	$24,000/month
500-1,000	17,000/month	16,000/month	33,000/month
1,000-1,500	5,000/month	16,000/month	21,000/month

CHAPTER IV

ANTHRACITE SOURCES

A. GEOLOGY OF THE ANTHRACITE FIELDS

A.1 Physiography

The anthracite coal region lies within the Appalachian Mountain Section of the Valley and Ridge physiographic province. The anthracite coal measures comprise an area of approximately 484 square miles and are divided into four separate fields by distinct geologic boundaries. The largest of the fields, areally, is the Southern, followed by the Northern, Western Middle and Eastern Middle. Plate IV-1 is a map showing the location of the anthracite fields in relation to major Pennsylvania cities and towns. Plate IV-2 relates the fields to the physiographic provinces.

A.2 Topography

The topography of the anthracite area is dominated by the steep ridges separated by valleys which vary greatly in width. The Northern Field is a single valley whereas the Southern and Western Middle Fields comprise a series of small interconnected valleys. Instead of occupying a valley or series of valleys, the Eastern Middle Field is situated on high tableland which is approximately level. The maximum relief in the area is 2,000 feet and the local relief is generally between 600 feet and 1,000 feet.

A.3 Stratigraphy

The most recently deposited material in the coal fields, except in the southern portion of the Southern Field, is the glacial drift from the three Pleistocene glacial stages. Preglacial erosion has resulted in deeply buried valleys in many places, the most notable of these being the Wyoming Valley of the North Branch of the Susquehanna River. This hidden valley is at least 100 feet thick over an area of more than 20 square miles and is over 300 feet thick in one locality. Recent deposits of silt, sand and gravel are found along the streams of the area. They are the result of bedrock erosion, the reworking of glacial drift and the deposition of very fine coal or culm from coal washeries.

ANTHRACITE FIELDS OF NORTHEASTERN PENNSYLVANIA

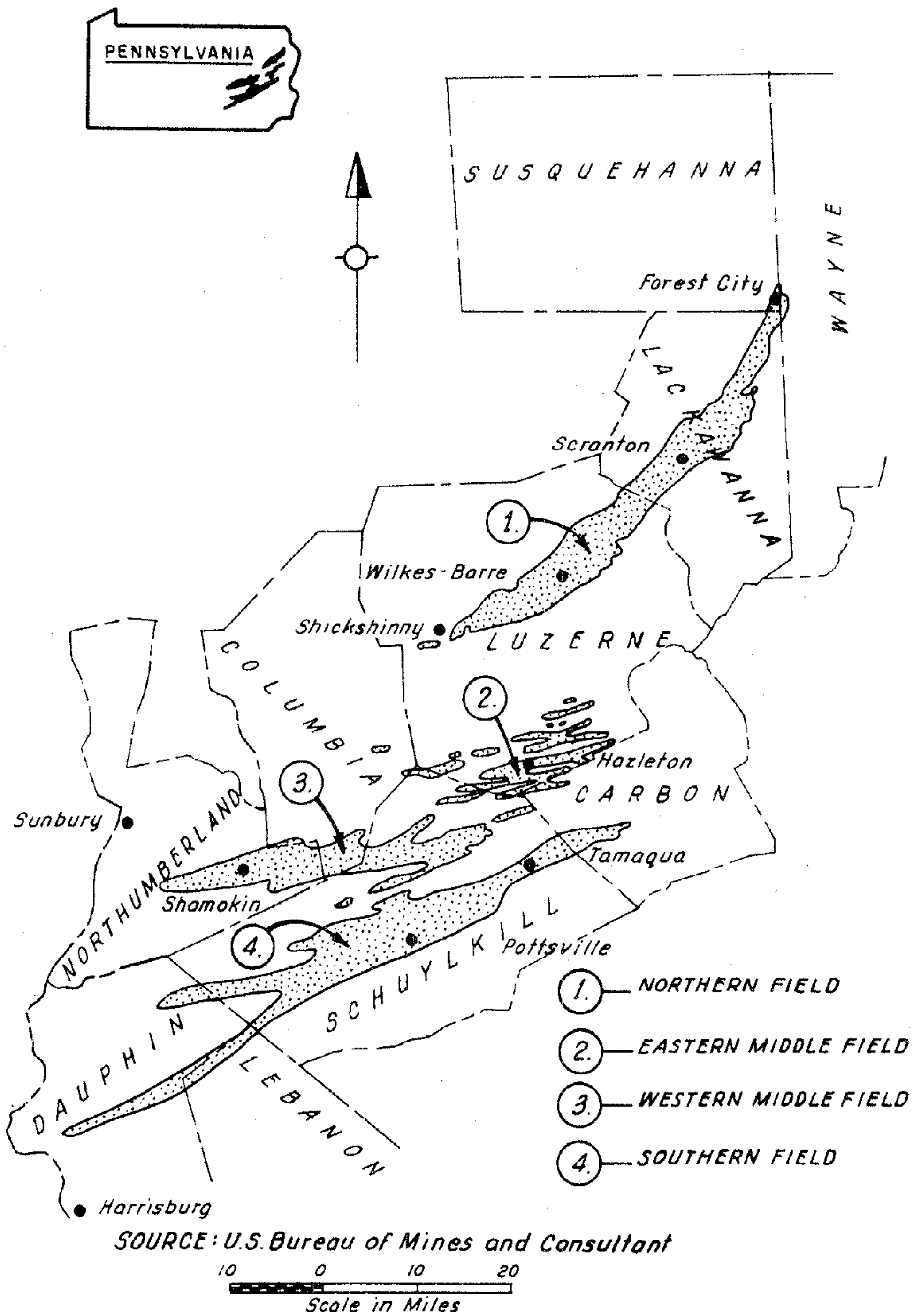
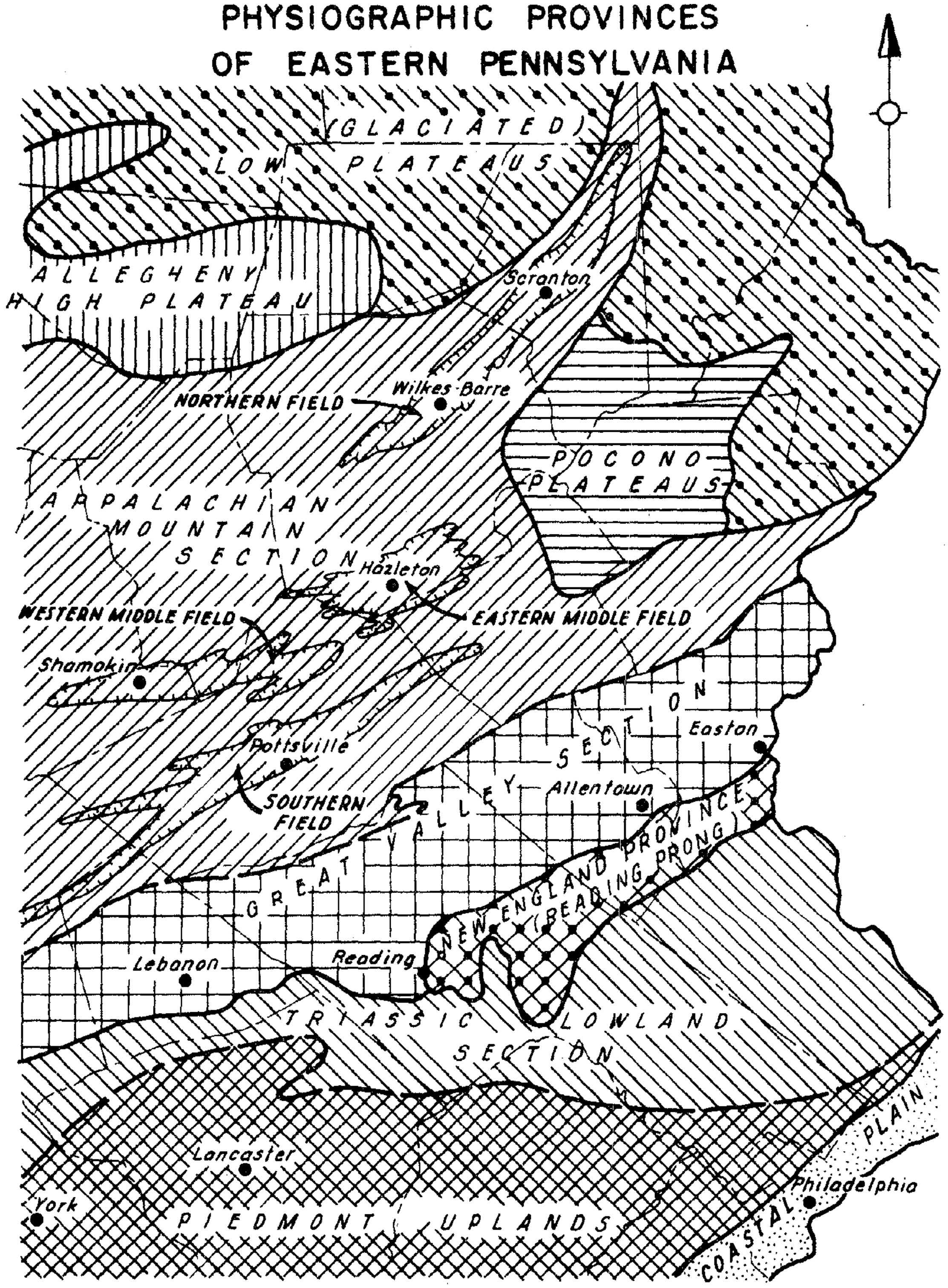


PLATE IV - 1

PHYSIOGRAPHIC PROVINCES
OF EASTERN PENNSYLVANIA



SOURCE: Pennsylvania Geologic Survey

PLATE IV - 2

The rock formations found in the anthracite fields are all of sedimentary origin. The coal bearing formations are the Llewellyn and the Pottsville. The Llewellyn formations consist of beds of sandstone, having a variable hardness and texture; shale; clay; black carbonaceous slate or shale; and coal beds which range from only a few inches thick to the massive Mammoth bed which is more than 50 feet thick over large areas. Brown or gray is the predominant color of the sandstones or shales. There are fireclays associated with the coal beds as well as in the zones of shale and sandstones between the coals. Unlike the bituminous fields of the western part of the state, limestones are non-existent, except in the Wyoming Valley. Since the rocks of the Llewellyn formation are not as resistant to erosion as the underlying Pottsville formation, they have formed reasonably flat valleys which are surrounded by ridges made up of Pottsville rocks.

The Pottsville formation is primarily a mass of quarzitic rocks comprised mostly of gray conglomerate, white, gray and brown sandstone, some thin beds of carbonaceous slate, and a few thin coal seams. The coal beds of the Pottsville formation are the most extensive and valuable in the west ends of the Southern and Western Middle Fields. As one progresses to the east the coal beds decrease in size and number. The bulk of the formation then is hard, coarse conglomerate whose outcrop forms an encircling ridge around each of the coal basins, protecting the coal beds of the overlying Llewellyn formation.

The Generalized Stratigraphic Sections, Plates IV-3, 4, 5 and 6, show the coals of the four anthracite fields, their relative positions and the average intervals between the beds.

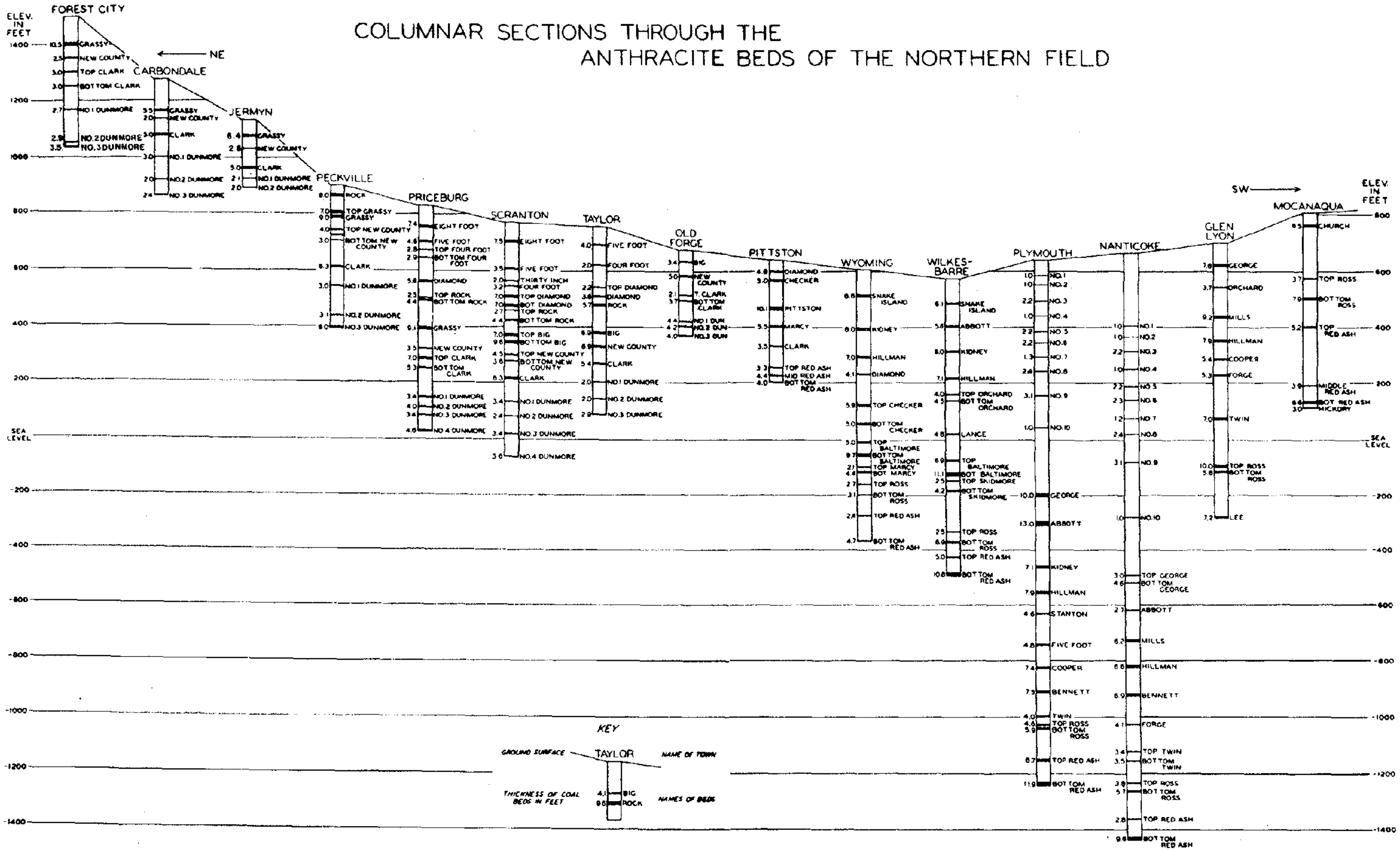
A.4 Structure

The geologic structure of the anthracite fields is rather complex. In the Northern Field the most prominent structural feature is the Lackawanna syncline. Another major fold in this area forms the series of anticlines and synclines which constitute the Eastern Middle Field. The rocks of the Llewellyn formation, which are found in the central cores of the synclinal basins, have been severely folded and contorted, with numerous minor faults.

The strata in the Southern Field are even more intensely folded so that they are overturned in many places. In some instances the faulting has fractured the coal into non-coherent masses which are difficult to mine.

The rocks of the Western Middle Field have also been folded into a series of alternating synclines and anticlines which trend in a east - northeast direction. The folding and faulting is not as severe as in the Southern Field and the dips of the strata are not as great.

COLUMNAR SECTIONS THROUGH THE ANTHRACITE BEDS OF THE NORTHERN FIELD

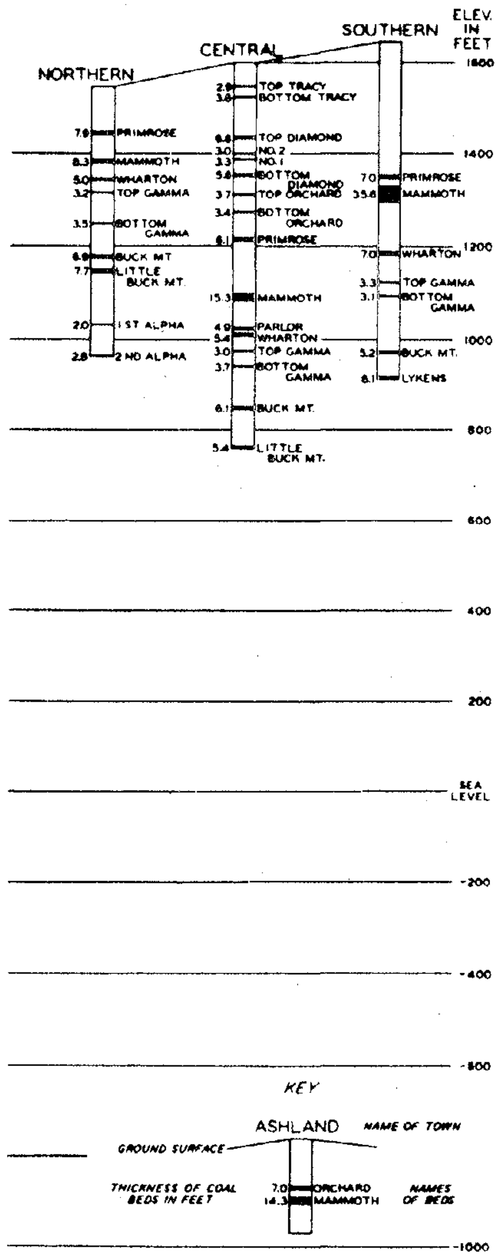


SOURCE: *Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite*

PLATE IV - 3

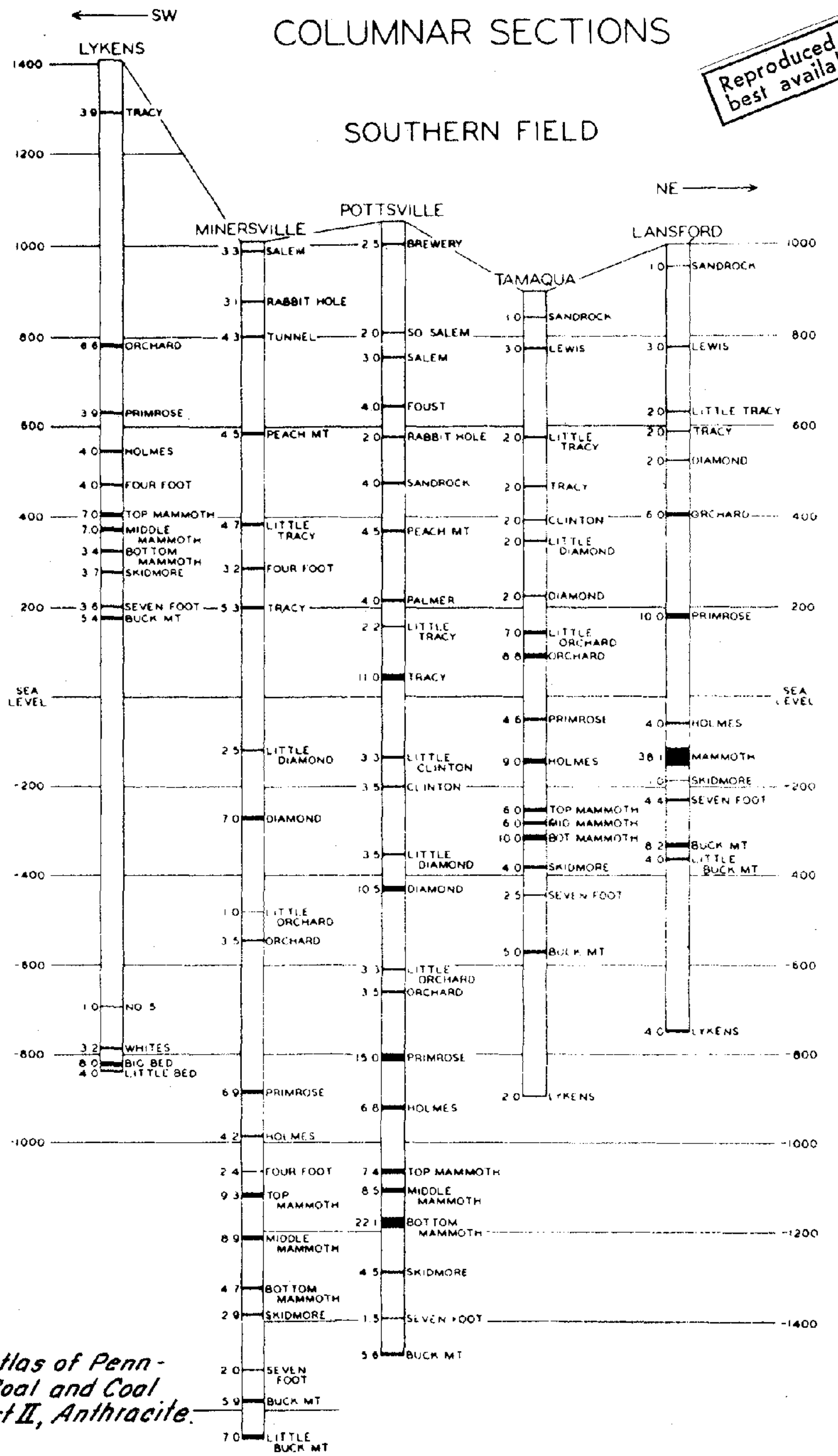
COLUMNAR SECTIONS

EASTERN MIDDLE FIELD



SOURCE: Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite.

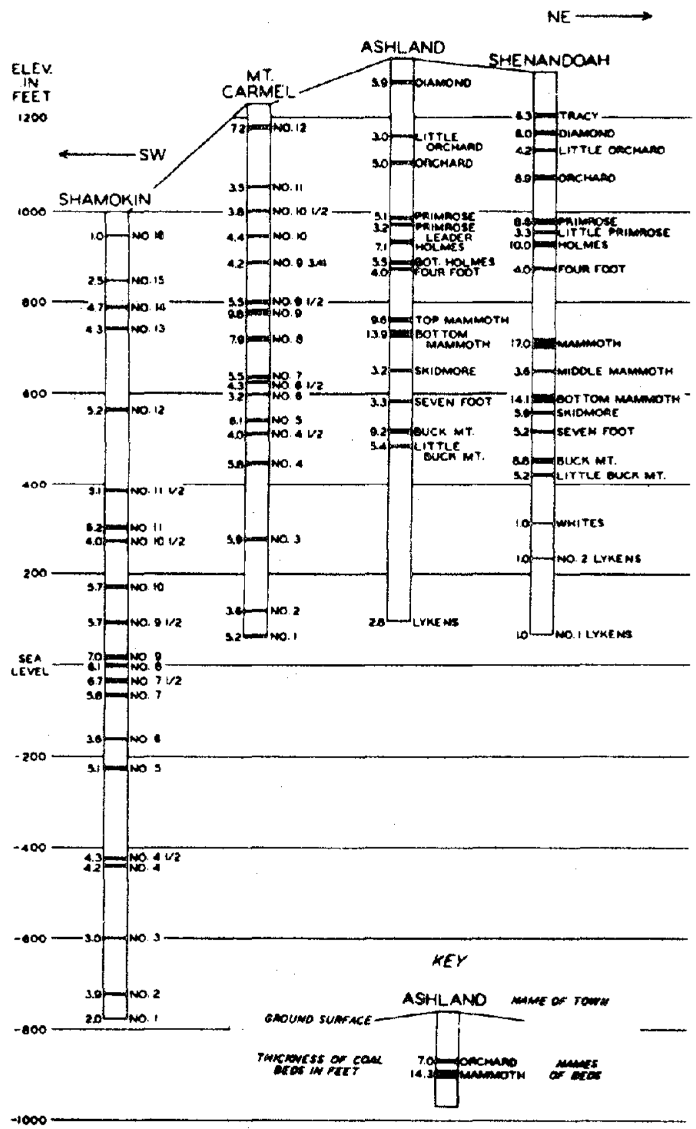
PLATE IV - 4



SOURCE: Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite.

PLATE IV - 5

COLUMNAR SECTIONS
WESTERN MIDDLE FIELD



SOURCE: Atlas of Pennsylvania
Coal and Coal Mining, Part II, Anthracite

PLATE IV - 6

B. COAL RESOURCES

B.1 Evaluation Technique

"Estimating the potential recoverable reserves of the four anthracite fields is a difficult problem in any case". This is a quote from Information Circular 72, Coal Reserves of Pennsylvania: Total, Recoverable, and Strippable (January 1, 1970). The figures of Appendix Table A in that publication were used as the base data in this report. As noted, that report includes coal thicknesses of 14 inches and up and is based on Progress Report 130 by Ashley[1] (1944). The resources of the four anthracite fields are shown by the pie diagram on Plate IV-7. The bulk of the coal remaining is in the Southern Field followed by the Western Middle, Northern and Eastern Middle Fields. The combined resources of the four fields according to our estimate is 17,418,000,000 net tons.[2]

In this report the location of the resources available are shown either by county or by 7½ minute U. S. Geologic Survey quadrangle, depending on the availability of updated information. The Northern and Eastern Middle Fields are shown using the former area delineation and the Southern and Western Middle Fields follow the latter scheme.

There has been little data published on the resources of the Northern and Eastern Middle Fields since the 1944 estimate by Ashley. The amount of coal in each county falling in these two fields was calculated for this report by multiplying the resources remaining in each county by a factor which is a percentage of the county which falls in the field. This percentage was determined using the original content figures given for the counties in Ashley (1944). For example, of the 630 million tons of coal in Carbon County, 110 million tons, or 17 percent, were calculated to be in the Eastern Middle Field. This procedure was followed for all the counties in the Northern and Eastern Middle Fields.

In the Southern Field, we have utilized the data from Geological Survey Professional Paper 602, which deals with the geology of the Klingerstown, Lykens, Minersville, Pine Grove, Swatara Hill, Tower City, Tremont and Valley View 7½ minute geologic quadrangles, and geologic investigation reports on

---

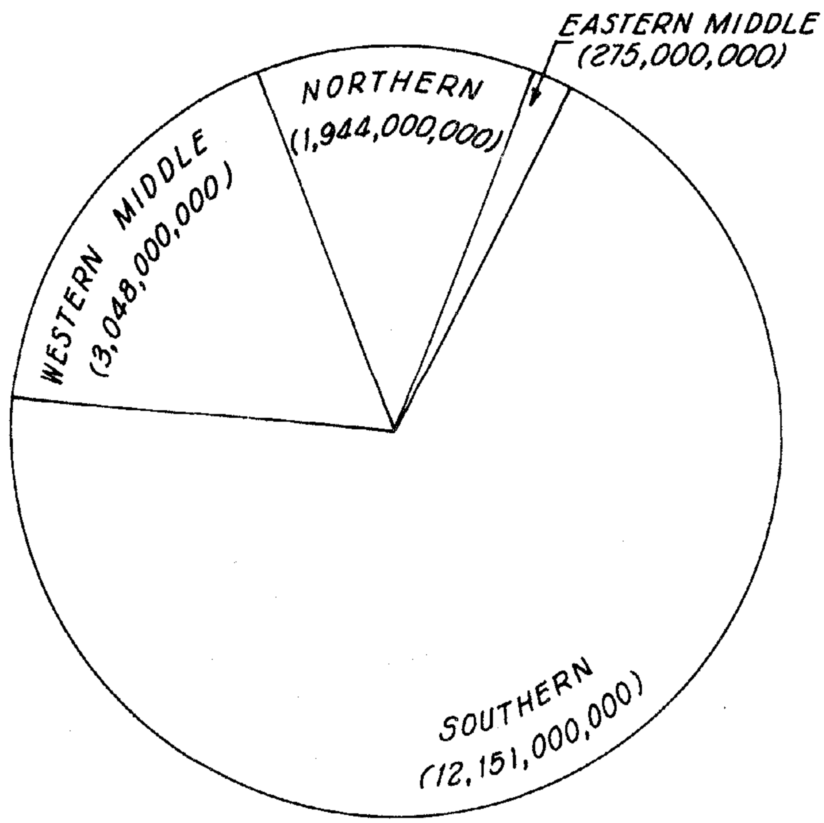
[1]George H. Ashley, Anthracite Reserves, Pennsylvania Topographic and Geologic Survey, 1945.

[2]Reserve estimates include only coal below the average valley floor. Due to the lack of data on mining it was not possible to estimate the reserves remaining above the valley floor.

ESTIMATE OF ANTHRACITE RESOURCES IN TONS

BY FIELD

1974



SOURCE: Prepared by Consultant based on Data from the Pennsylvania Bureau of The Topographic and Geologic Survey.

PLATE IV - 7

the Pottsville and Orwigsburg quadrangles to update the original estimates.[1] In Professional Paper 602 it was estimated that the eight counties in the report area contained approximately 7.6 billion net tons of coal. A further breakdown of this total allotted 6.5 billion tons to Schuylkill County, 0.66 billion tons to Lebanon County and 0.44 billion tons to Dauphin County. These amounts of coal were prorated to the various quadrangles using typical structure sections from each quadrangle, measuring the length of the seams and calculating the area of the coal using the average coal thickness for the respective seams. The complexity of the structure sections determined the number which was used to calculate coal in a quadrangle. The final volume was computed using the average end area method. From sample calculations it was estimated that approximately 30 percent of the coal lies within 1,000 feet of the valley floor, 30 percent is between 1,000 feet and 2,000 feet, 15 percent is between 2,000 and 3,000 feet and 25 percent is at a depth of 3,000 or more. The quantities for the Orwigsburg and Pottsville quadrangles are from the aforementioned investigation reports. The proration for the Tamaqua, Delano and Nesquehoning quadrangles are based on data from the Second Geologic Survey and it was estimated that the coal was originally distributed as follows:

V.F. - 1,000'	40 percent
1,000' - 2,000'	30 percent
2,000' - 3,000'	20 percent
3,000'+	10 percent

In order to arrive at the present resources available, the total production and losses were estimated for each of the quadrangles, based on the information available for the counties, and were subtracted from the original resource figures.

The coal remaining in the Western Middle Field was also determined using the average end area method; however, the area of coal in each of the structure cross sections published by the U. S. Geologic Survey was calculated. The sections were first reviewed and a line representing the average valley floor was drawn on each cross section and the strata below were divided into vertical increments of 500 feet. The lengths of the coal seams remaining in each zone of 500 feet were then measured and tabulated. The areas were then determined using the average seam thicknesses. The average end area method was used for the final volume computation after measuring the average distances between the cross sections.

---

[1]Gordon H. Wood, Jr., and others, Geology of the West Central Part of the Southern Anthracite Field and Adjoining Areas, Pennsylvania, U. S. Geological Survey Professional Paper 602, 1969, p.138.

It was assumed that the coal has a unit weight of 92 pounds per cubic foot in all the calculations.

B.2 Northern Field

The Northern Field consists of essentially one large synclinal basin which covers an area of approximately 176 square miles. The Field has a length of 55 miles and falls primarily in Luzerne and Lackawanna Counties, with a small portion in Susquehanna and Wayne Counties, as shown on Plate IV-8. Due to the flat lying nature of the beds the first extraction of coal took place at the surface where the seams outcropped. This procedure was followed by the driving of slopes and the development of shafts to the deeper flat lying beds as the demand for coal increased. Deep mine development has taken place to an altitute of 900± feet below sea level or to a depth of approximately 1,500 feet below the valley floor at Wilkes-Barre. Proceeding to the southwest along the axis of the basin, the coal reaches its lowest level at about 2,000 feet below the valley floor near Nanticoke.

There has been little recent work in updating the resource estimates of this Field and since such an undertaking is beyond the scope of this project, the Consultant has relied upon the latest published data of the Pennsylvania Bureau of Topographic and Geologic Survey[1]. Plate IV-9 is a pie diagram which shows the total available resources for the Northern Field. As shown, the bulk of the coal is in Luzerne County and in all probability most of it is more than 1,000 feet below the valley floor.

Future deep mining of coal in the Wyoming and Lackawanna Valleys will be a problem because of the high water table and because of the dense population centers which have developed in the area. Subsidence has occurred in the distant and recent past and the potential for subsidence must be considered in any future mining plans.

B.3 Eastern Middle Field

The Eastern Middle Field is situated in the central portion of the Anthracite Region, with most of its area in southern Luzerne County. The remainder of the field falls in Carbon, Columbia and Schuylkill Counties (see Plate IV-10). The area covered is only 33 square miles and, unlike the Northern Field, the Eastern Middle Field is divided into a number of isolated basins. The greatest amount of cover over the coal in this field occurs in the Hazleton, Diamond and Stockton basins where the lowest coal occurs at depths between 1,000 and 1,200 feet.

---

[1]William E. Edmunds, Coal Reserves of Pennsylvania: Total Recoverable, and Strippable (January 1, 1970), Pennsylvania Bureau of Topographic and Geologic Survey, IC-72, 1972.

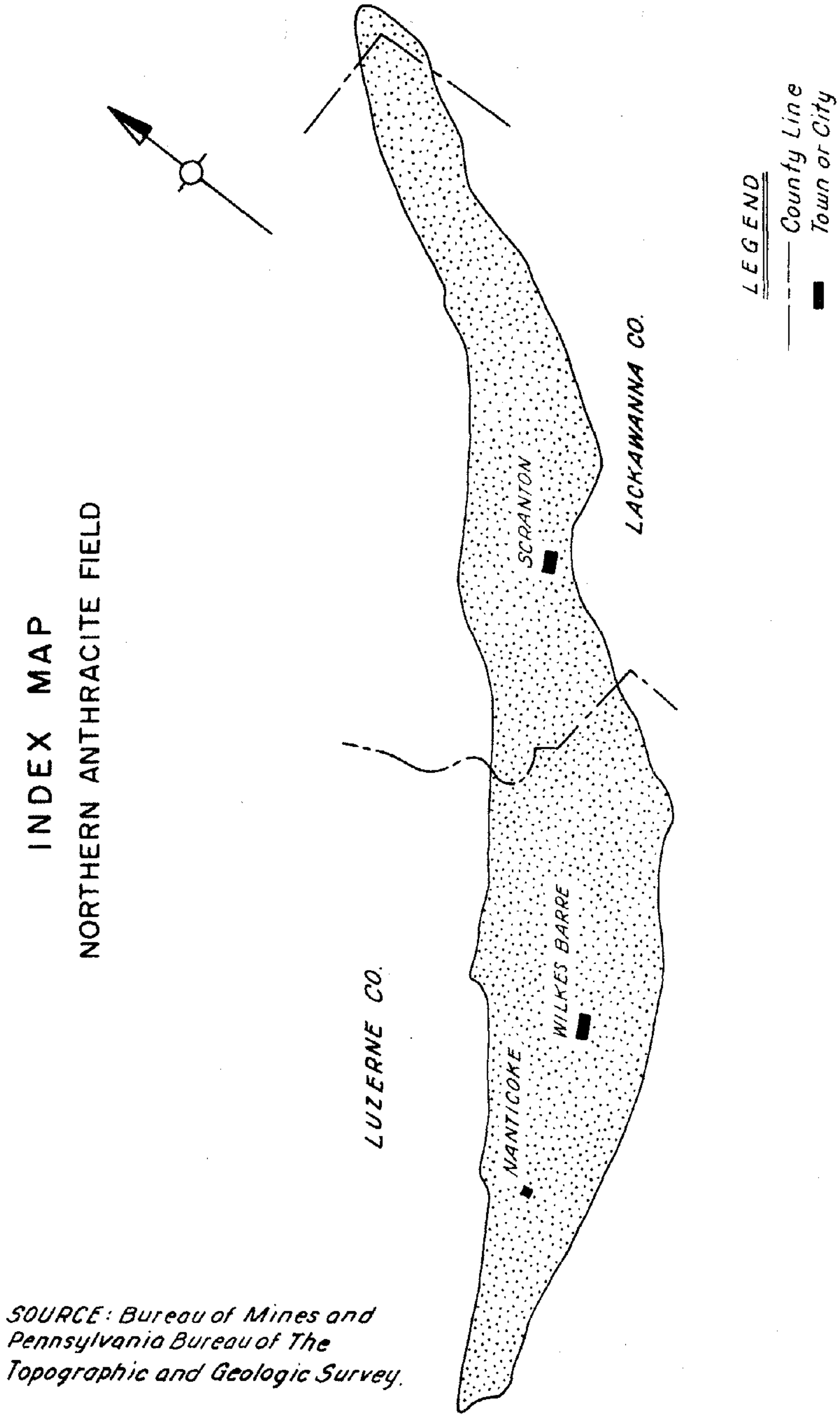

INDEX MAP
NORTHERN ANTHRACITE FIELD
LEGEND
County Line
Town or City
LACKAWANNA CO.
SCRANTON
LUZERNE CO.
WILKES BARRE
NANTICOKE
SOURCE: Bureau of Mines and Pennsylvania Bureau of The Topographic and Geologic Survey.

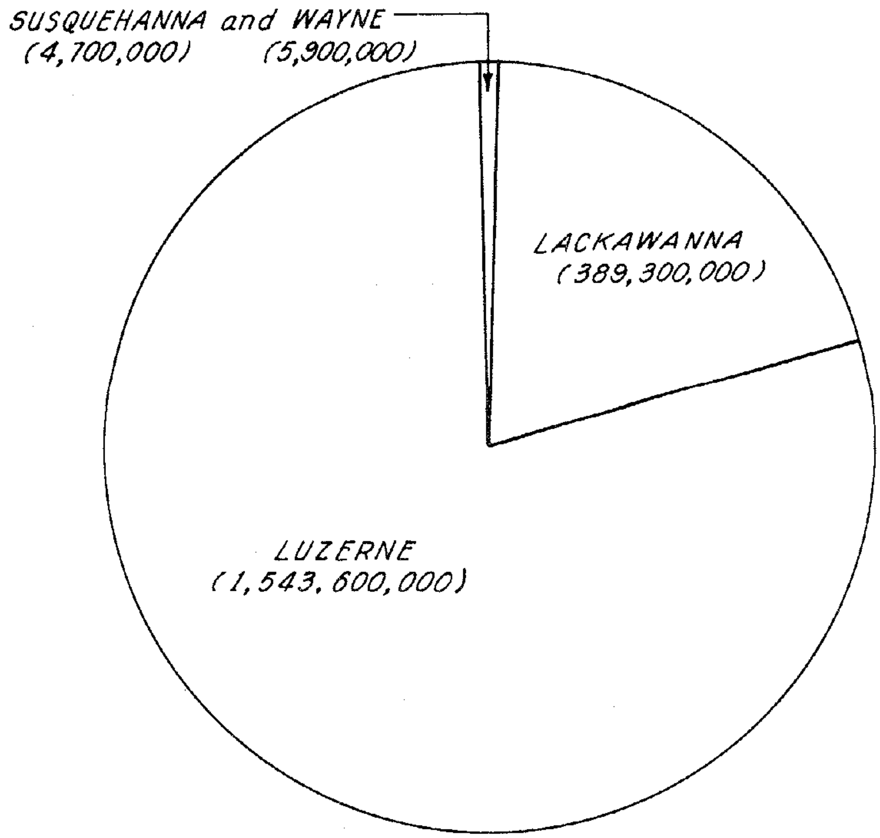
PLATE IV - 8

ESTIMATE OF ANTHRACITE RESOURCES IN TONS

BY COUNTY

NORTHERN FIELD

1974

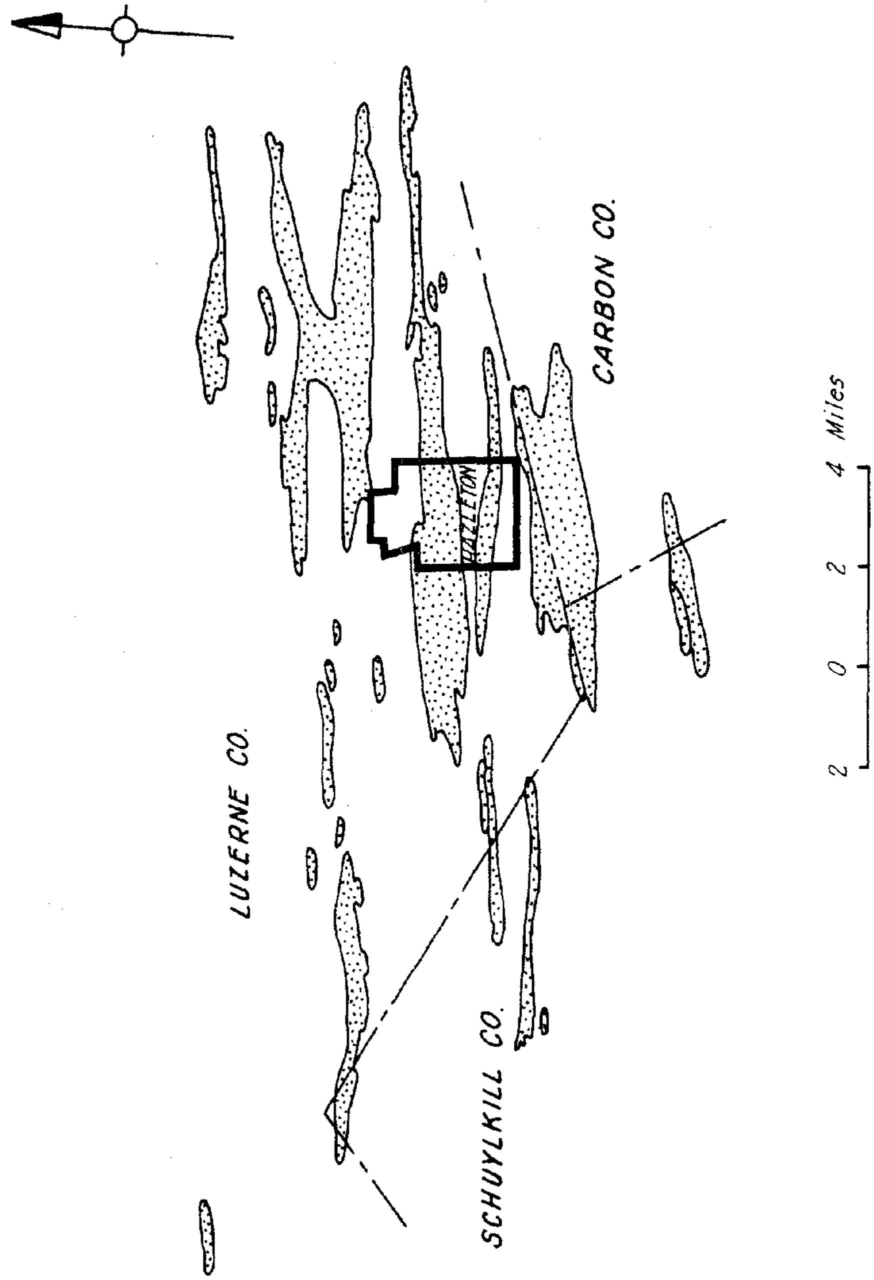


SOURCE: Prepared by Consultant based on Data from Pennsylvania Bureau of The Topographic and Geologic Survey.

PLATE IV - 9

INDEX MAP

EASTERN MIDDLE ANTHRACITE FIELD



SOURCE: Bureau of Mines and Pennsylvania Bureau of The Topographic and Geologic Survey.

PLATE IV - 10

The most recent detailed study related to the resources of the Eastern Middle Field was completed by the Bureau of Mines in 1950[1]. The scope of the study was to determine the inundated reserves in each mine pool. In all, 32 mine pools were studied. The estimate considered only coal which was amenable to extraction by the methods available at the time and, in general, the minimum thickness considered was 36 inches. According to the report, 15 of the basins have been mined to exhaustion or have only a small tonnage of coal remaining in place.

The figures shown on Plate IV-11 are from the 1970 estimate of coal reserves, published by the Pennsylvania Bureau of Topographic and Geologic Survey.[2] No detailed study has been made to determine exactly which basins contain the coal; however, the data available does show that the coal remaining is within 1,200 feet of the ground surface in the deepest basin. As in the Northern Field, most of the coal remaining in place is in Luzerne County.

B.4 Southern Field

The Southern Field is the largest of the four anthracite fields, occupying an area of 181 square miles. The central section of the field is in Schuylkill County and the "fishtail" ends of the basin are in Dauphin, Lebanon, and Carbon Counties (see Plate IV-12). It is in this field that the coal beds have the steepest pitches. In some instances the forces which have created the synclinal basins have been so great that the beds are overturned at some locations.

There has been a great deal of activity in recent years in the geologic mapping of the Southern Field whereby it has been possible to revise the estimate of the anthracite resources. The United States Geological Survey report published in 1969 has already been mentioned. Also, two miscellaneous geologic investigation reports, containing updated estimates of the coal resources in the Pottsville and Orwigsburg quadrangles, were published in 1972.[3] [4] Estimates for the Delano, Tamaqua and Nesquehoning quadrangles are based on data from Pennsylvania's Second Geologic Survey.

---

[1]S. H. Ash, and others, Inundated Anthracite Reserves: Eastern Middle Field of Pennsylvania, U. S. Bureau of Mines, Bulletin 491, 1950.

[2]Edmunds, op. cit.

[3]Gordon H. Wood, Jr., Geologic Map of Anthracite-Bearing Rocks in the Pottsville Quadrangle, Schuylkill County, Pennsylvania, U. S. Geological Survey, Map I-681, 1972.

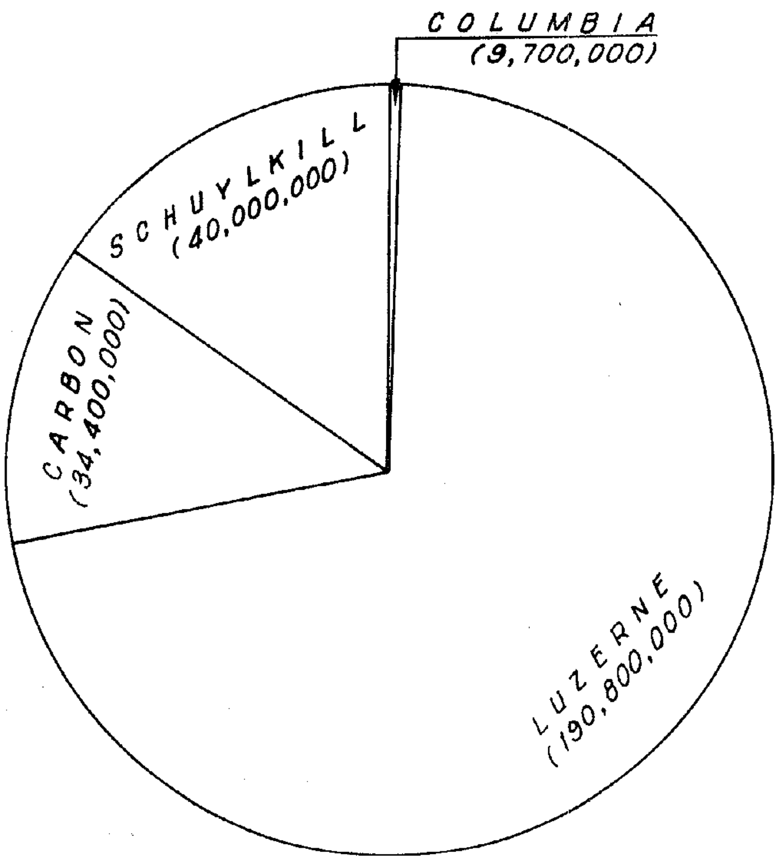
[4]Gordon H. Wood, Jr., Geologic Map of Anthracite-Bearing Rocks in the North Part of the Orwigsburg Quadrangle, Schuylkill County, Pennsylvania, U. S. Geological Survey, Map I-689, 1972.

ESTIMATE OF ANTHRACITE RESOURCES IN TONS

BY COUNTY

EASTERN MIDDLE FIELD

1974



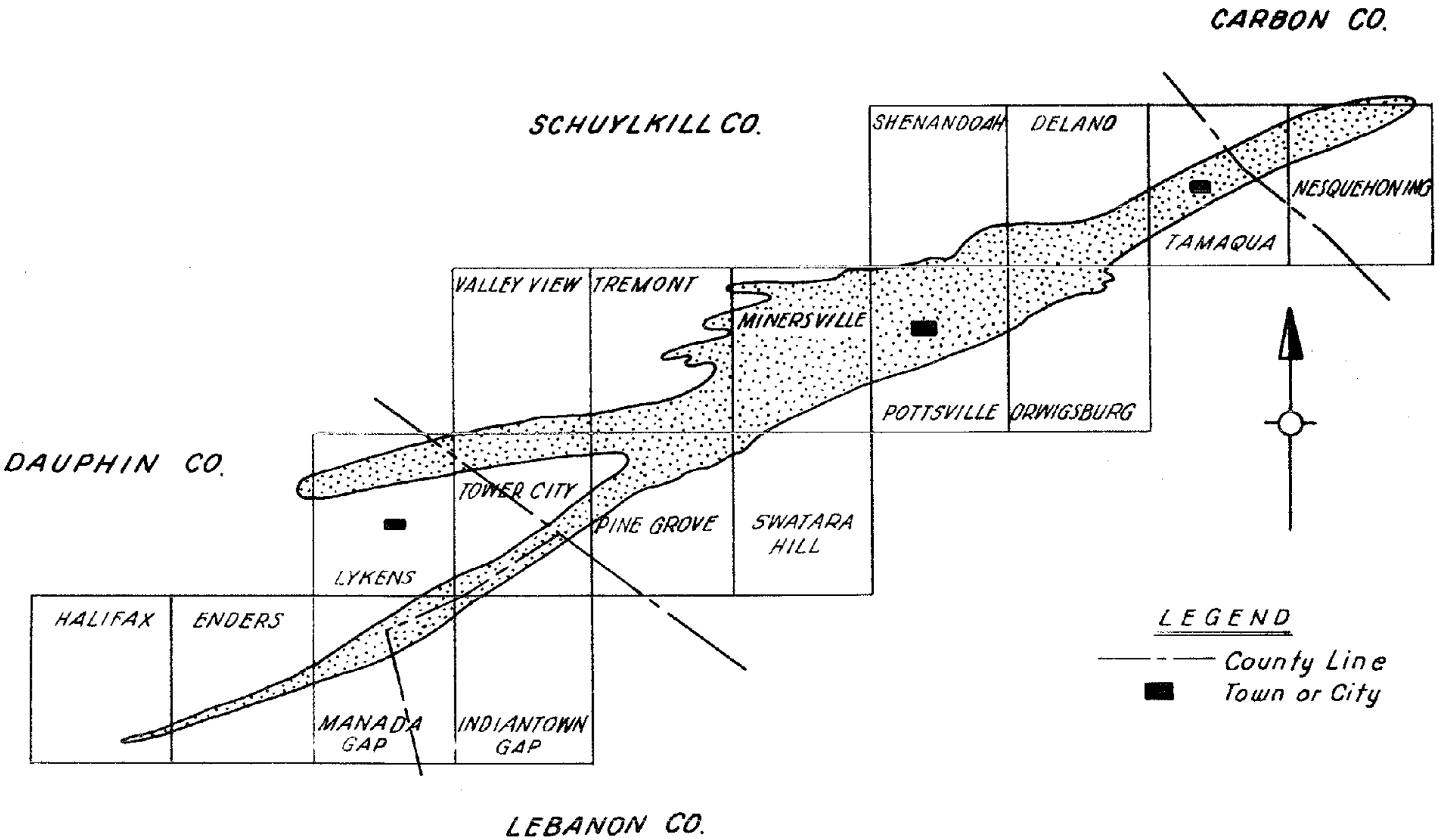
SOURCE: Prepared by Consultant based on Data from Pennsylvania Bureau of The Topographic and Geologic Survey.

PLATE IV - 11

INDEX MAP

SOUTHERN ANTHRACITE FIELD

(LOCATION OF U.S.G.S. QUADRANGLES)



SOURCE: U.S. Geological Survey

PLATE IV - 12

The total anthracite resources estimated for each quadrangle are shown on Plate IV-13. As shown, the Pottsville and Minersville quadrangles, which are located in the central part of the Southern Field, contain 40 percent of the resources available.

Table IV-1 is a summary of the anthracite resources of the Southern Field showing the location by U.S.G.S. 7½ minute quadrangle and the amount of coal at intervals of 1,000 feet below the average valley floor. Generally, between 30 and 40 percent of the original coal was located in the first increment of 1,000 feet. The second zone of 1,000 feet contains approximately 30 percent and there is between 15 and 23 percent in the next 3,000 feet. It is estimated that between ten and 25 percent of the coal is to be found beyond 3,000 feet.

B.5 Western Middle Field

As shown on Plate IV-14 the Western Middle Field is a basin traversing six U.S.G.S. 7½ minute quadrangle maps in a more or less east-west direction. The length of the Field is 33 miles and the area included within its boundaries is 94 square miles. Geologically, the conditions are such that mining has been conducted on pitches varying from level to vertical.

The results of the volume calculation explained in Section B.2 are contained in Table IV-2 and are shown graphically in the pie diagram on Plate IV-15.

B.6 Strippable Resources

There is no published data indicating either the original in-place strippable resources or the strippable resources remaining. However, for the purposes of this study an attempt has been made to determine the amount of strippable coal remaining in all the fields. In estimating the strippable resources it was assumed that any coal within 150 feet of the ground surface can be considered strippable.

The strippable resources remaining are computed as follows:

	Estimate of Strippable Resources (Millions of Net Tons)			
	Northern	Eastern Middle	Western Middle	Southern
Original Strippable Resources	915	205	600	720
Strip Mine Production to 1972	- 52	- 59	- 85	-208
Original Amount of Strippable Coal Lost to Deep Mining	(50%)-458	(50%)-103	(50%)-300	(25%)-182
Probable Strippable Resources	405	43	215	330

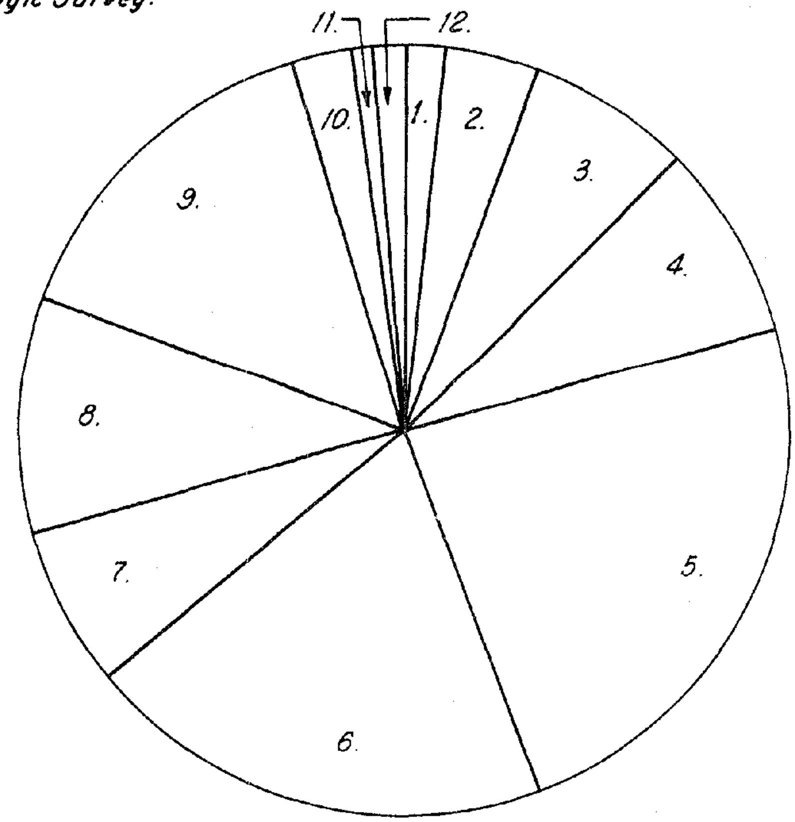
ESTIMATE OF ANTHRACITE RESOURCES IN TONS

BY U. S. G. S. QUADRANGLE

SOUTHERN FIELD

1974

SOURCE: Prepared by Consultant based on Data from the U.S. Geological Survey and Pa. Bureau of The Topographic and Geologic Survey.



LEGEND

		NET TONS
1.	NESQUEHONING	201,700,000
2.	TAMAQUA	465,900,000
3.	DELANO	819,900,000
4.	ORWIGSBURG	950,000,000
5.	POTTSVILLE	2,851,400,000
6.	MINERSVILLE	2,398,700,000
7.	TREMONT	814,800,000
8.	PINE GROVE	1,177,200,000
9.	TOWER CITY	1,781,900,000
10.	LYKENS	331,000,000
11.	ENDERS	143,800,000
12.	MANADA GAP	214,700,000

PLATE IV - 13

TABLE IV-1

ESTIMATED COAL RESOURCES
(Net Tons)

Southern Field
1974

Depth/ Quadrangle	Average Valley Floor to 1,000 Feet	1,000 Feet To 2,000 Feet	2,000 Feet To 3,000 Feet	3,000+ Feet
Nesquehoning	Insignificant	62,000,000	93,000,000	46,000,000
Tamaqua	125,000,000	170,000,000	114,000,000	57,000,000
Delano	220,000,000	300,000,000	200,000,000	100,000,000
Orwigsburg	255,000,000	348,000,000	232,000,000	116,000,000
Pottsville	518,000,000	1,014,000,000	796,000,000	523,000,000
Minersville	351,000,000	878,000,000	439,000,000	731,000,000
Tremont	119,000,000	298,000,000	149,000,000	249,000,000
Pine Grove	172,000,000	431,000,000	215,000,000	359,000,000
Tower City	420,000,000	584,000,000	292,000,000	486,000,000
Lykens	54,000,000	119,000,000	58,000,000	100,000,000
Enders	23,000,000	52,000,000	26,000,000	43,000,000
Manada Gap	34,000,000	77,000,000	39,000,000	65,000,000

Source: Prepared by Consultant based on data from:

[1]Second Geological Survey of Pennsylvania 1883, and William C. Edmunds, Coal Reserves of Pennsylvania: Total, Recoverable and Strippable (January 1, 1970), Pennsylvania Geological Survey, Fourth Series, IC-72, 1972.

[2]G. H. Wood, Jr., Geologic Map of Anthracite-Bearing Rocks in the North Part of the Orwigsburg Quadrangle, Schuylkill County, Pennsylvania: U. S. Geological Survey, Miscellaneous Geological Inv. Map I-689, 1972.

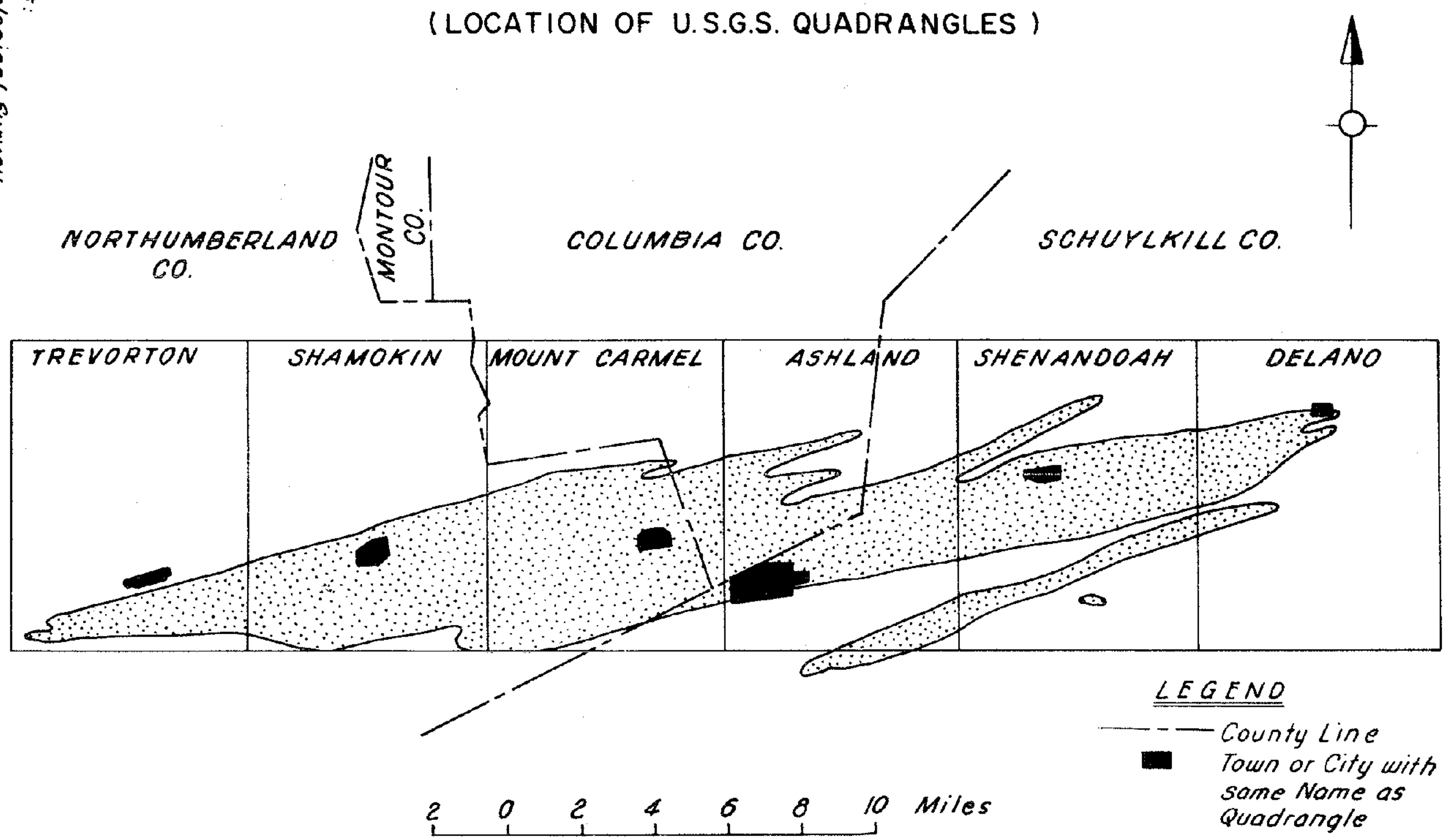
[3]G. H. Wood, Jr., Geologic Map of Anthracite-Bearing Rocks in the Pottsville Quadrangle, Schuylkill County, Pennsylvania: U. S. Geological Survey, Miscellaneous Geological Inv. Map I-681, 1972.

[4]G. H. Wood, Jr., J. P. Trexler, and Thomas M. Kehn, Geology of West-Central Part of the Southern Anthracite Field and Adjoining Areas, Pennsylvania, U. S. Geological Survey, Geologic Survey Prof. Paper 602, 1969.

SOURCE:
U.S. Geological Survey

INDEX MAP

WESTERN MIDDLE ANTHRACITE FIELD
(LOCATION OF U.S.G.S. QUADRANGLES)

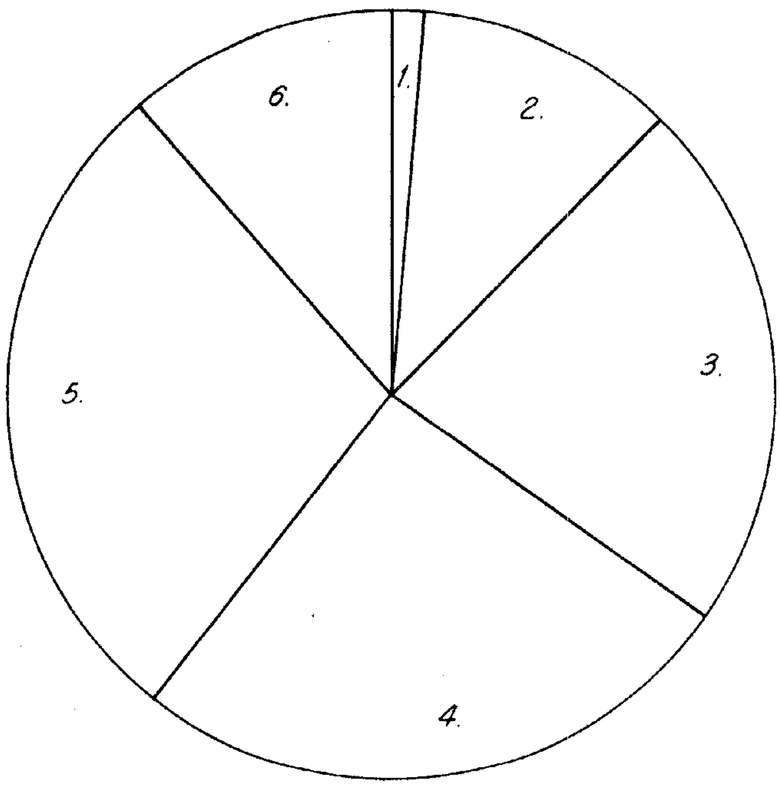


IV - 22

PLATE IV - 14

ESTIMATE OF ANTHRACITE RESOURCES IN TONS

BY U.S.G.S. QUADRANGLE
WESTERN MIDDLE FIELD
1974



L E G E N D

1.	DELANO	35,900,000	NET TONS
2.	SHENANDOAH	307,500,000	
3.	ASHLAND	678,300,000	
4.	MOUNT CARMEL	789,300,000	
5.	SHAMOKIN	843,300,000	
6.	TREVORTON	393,800,000	

SOURCE: Prepared by Consultant based on Data from the U.S. Geological Survey and Pa. Bureau of The Topographic and Geologic Survey.

PLATE IV - 15

TABLE IV-2

ESTIMATED COAL RESOURCES
(Net Tons)

Western Middle Field
1974

Depth/ Quadrangle	Avg. Valley Floor To 500 Feet	500 Feet To 1,000 Feet	1,000 Feet To 1,500 Feet	1,500 Feet To 2,000 Feet	2,000+ Feet
Trevorton	110,000,000	145,000,000	89,000,000	44,000,000	5,000,000
Shamokin	163,000,000	256,000,000	236,000,000	150,000,000	39,000,000
Mt. Carmel	323,000,000	285,000,000	128,000,000	40,000,000	13,000,000
Ashland	161,000,000	199,000,000	186,000,000	132,000,000	-
Shenandoah	122,000,000	104,000,000	70,000,000	11,000,000	-
Delano	17,000,000	17,000,000	3,000,000	-	-

Source: Prepared by Consultant based on data from:

[1]H. H. Arndt, and others, Geology of Anthracite in the Southern Part of the Trevorton Quadrangle: U.S. Geological Survey Coal Investigations Map C-48, 1963.

[2]H. H. Arndt, and others, Geology of Anthracite in the Western Part of the Shamokin Quadrangle: U.S. Geological Survey Coal Investigations Map C-47, 1963.

[3]Walter Danilchik, and others, Geology of Anthracite in the Eastern Part of the Shamokin Quadrangle: U.S. Geological Survey Coal Investigations Map C-46, 1962.

[4]H. E. Rothrock, and others, Geology of Anthracite in the Mount Carmel Quadrangle: U.S. Geological Survey Coal Investigations Maps C-3, C-7, C-10, and C-12, 1950, 1951, 1953.

[5]B. R. Haley, and others, Geology of Anthracite in the Ashland Quadrangle: U.S. Geological Survey Coal Investigations Maps C-13 and C-14, 1953.

[6]T. M. Kehn, and H. C. Wagner, Geology of Anthracite in the Eastern Part of the Shenandoah Quadrangle: U.S. Geological Survey Coal Investigations Map C-19, 1956.

[7]Walter Danilchik, and others, Geology of Anthracite in the Western Part of the Shenandoah Quadrangle: U.S. Geological Survey Coal Investigations Map C-21, 1955.

[8]J. A. Maxwell, and H. E. Rothrock, Geology of Anthracite in the Western Part of the Delano Quadrangle: U.S. Geological Survey Coal Investigations Map C-25, 1955.

The estimates of the amount of strippable coal lost to deep mining are based upon a review of the representative cross sections of the four fields. As in the total resource estimates shown earlier, the above figures include all coal seams of 14 inches and thicker.

C. REFUSE BANKS

The first record of anthracite production resulting from washery and bank materials production was made in 1894. Since that time production from this source generally increased and reached a peak production of over ten and one-half million tons in 1944. In 1967, the tonnage of anthracite produced from culm banks exceeded the deep mine tonnage for the first time, and has remained at about 32 percent of the total production.

According to Bureau of Mines' data contained in Information Circular 8409, which is a comprehensive study of anthracite refuse banks, there were 863 refuse banks in the Anthracite Region.[1] Of this total, 63 of the banks had volumes of 10,000 cubic yards or less. Those containing more than 10,000 cubic yards had a total volume of 910,080,000 cubic yards and occupied an area of more than 12,000 acres.

The refuse material contained in the piles is classified as processed or unprocessed. Processed material is that rejected by processing operations in a breaker or preparation plant. The unprocessed refuse is that material which is brought to the surface and deposited without any handling by the breaker or preparation plant. The refuse material from modern preparation plants generally contains less than five percent salable coal.

Table IV-3 summarizes the volume of refuse banks in the Region and estimates their productive life.

The percentages used in computing the tonnage of salable coal in the refuse piles is a result of a review of available literature and interviews with industry personnel. These figures are considered to be region-wide averages - the characteristics of individual piles can vary greatly from these figures.

---

[1]James C. McCartney and Ralph H. Whaite, Pennsylvania Anthracite Refuse - A Survey of Solid Waste from Mining and Preparation, IC-8409, 1969.

TABLE IV-3

ESTIMATED VOLUME OF REFUSE BANKS BY TYPE OF MATERIAL

Pennsylvania Anthracite Region
1967, 1974

Type of Material	Volume of Material (Thousands of Cubic Yards) Northern	Eastern Middle	Western Middle	Southern
Breaker Refuse	194,620	39,500	150,090	1,900
Silt	7,970	7,420	2,920	4,840
Breaker Refuse and Silt	30,640	6,850	68,660	33,090
Mine Refuse	86,630	1,080	16,600	-
Tunnel Rock	-	150	-	-
Mixture	45,600	20,160	45,110	146,250
Totals (1967)	365,460	75,160	283,380	186,080

Type of Material and Assumed Percent of Coal	Volume of Coal (Thousands of Cubic Yards) Northern	Eastern Middle	Western Middle	Southern
Coal in Breaker Refuse (15%)	29,193	5,940	22,514	285
Coal in Silt (25%)	1,993	1,855	730	1,210
Coal in Breaker Refuse and Silt (25%)	7,660	1,713	17,165	8,273
Totals	38,846	9,508	40,409	9,768
Conversion to Tonnage (Thousands of Tons)	47,004	11,505	48,894	11,819

Total Tonnage (All Fields)	119,222,000 tons
Bank and Washery Production Since 1966	22,644,000 tons
Total Tonnage Remaining	96,578,000 tons
Average Production 1967-1973	2,800,000 tons/year
Probable Life	35 years

Source: Prepared by Consultant based on data from:

James C. McCartney, and Ralph H. Whaite, Pennsylvania Anthracite Refuse - A Survey of Solid Waste from Mining and Preparation, IC-8409, 1969.

D. QUANTITIES OF COAL WITH VARIOUS PHYSICAL AND CHEMICAL PROPERTIES

In addition to the determination of the quantity and location of the resources available, an estimate of the coal available with certain physical and chemical properties has been made. The properties considered as being most important are heat value, ash content, grindability, percentage of volatile material, sulphur content and percentage of fixed carbon.

Some of the properties vary depending on the geologic forces at the time of the formation of the coal and others show no apparent relationship to geologic or geographic setting. Heat value shows an increase progressing from the southeast to the northwest and west of the Anthracite Region, and shows an interrelationship with the percentage of volatile matter.

Ash content does not show any distinct relationship to geographical location. It is dependent on the size of the coal, the composition of the seam from which it is mined, and the efficiency of the preparation plant in cleaning.

Coals from the Northern Field have the lowest grindability indices and are the hardest to grind. Those from the western portions of the Western Middle and Southern Fields are the softest; those remaining are in the intermediate range of grindability.

The percentages of fixed carbon show a pattern of decreasing order from east to west and south to north.

The data available shows that the sulphur content ranges from 0.3 to 1.2 percent. The sulphur content is highest in the western ends of the Southern and Western Middle Fields. Toward the eastern portions of these two Fields they tend to be lower. In the Northern Field the range in sulphur content is broad and is geographically random.

The amounts of coal having the aforementioned physical characteristics were determined by one of two methods. If the property showed a distinct pattern across the region, the quantity of coal was assumed to be in proportion to the areal portions of the field falling within the band defined by the numerical values defining that property. In those cases where there was no distinct pattern exhibited, the percentage of samples in each grade range for each field was determined. The total amount of coal in the field was then multiplied by this percentage to calculate the volume in each grade.

It should be pointed out that the physical and chemical data available are high graded; that is, they represent very select samples. The face samples taken from the seams are handpicked and contain virtually no impurities and the tipple and delivered samples are taken from coal which has been processed and cleaned.

The following tables show the estimated amount of coal remaining underground which has the previously discussed properties.

TABLE IV-4

FIXED CARBON
(Percentage)
1974

Estimate of
Tonnages Remaining

Range/ Field	91% to 93%	93% to 94%	94% to 95%	95% to 96%	96% to 97%
Northern	350,000,000	428,000,000	739,000,000	428,000,000	
Eastern Middle				94,000,000	181,000,000
Western Middle	366,000,000	122,000,000	640,000,000	1,798,000,000	122,000,000
Southern	3,767,000,000	1,094,000,000	2,187,000,000	4,010,000,000	1,215,000,000

Source: Prepared by Consultant based on data from:

G. F. Deasy, and P. R. Griess, Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite, The Pennsylvania State University, Bulletin of the Mineral Industries Experiment Station, Number 80, 1963.

TABLE IV-5

ASH CONTENT
(Percentage)
1974

Estimate of Tonnages Remaining

Range/Field	8% to 11%	11% to 14%	14% to 19%
Northern	642,000,000	778,000,000	525,000,000
Eastern Middle	91,000,000	138,000,000	47,000,000
Western Middle	1,097,000,000	1,311,000,000	640,000,000
Southern	1,580,000,000	7,898,000,000	2,673,000,000

Source: Prepared by Consultant based on data from:

G. F. Deasy, and P. R. Griess, Atlas of Pennsylvania Coals and Coal Mining, Part II, Anthracite, The Pennsylvania State University, Bulletin of the Mineral Industries Experimental Station, Number 80, 1963.

TABLE IV-6

GRINDABILITY
(Hardgrove Grindability Index)
1974

Estimate of Tonnages Remaining

Range/ Field	30 to 40	40 to 50	50 to 60	60 to 70
Northern	1,944,000,000			
Eastern Middle		234,000,000	41,000,000	
Western Middle		1,707,000,000	823,000,000	518,000,000
Southern		6,076,000,000	2,916,000,000	3,159,000,000

Source: Prepared by Consultant based on data from:

G. F. Deasy, and P. R. Griess, Atlas of Pennsylvania Coals and Coal Mining, Part II, Anthracite, The Pennsylvania State University, Bulletin of the Mineral Industries Experimental Station, Number 80, 1963.

TABLE IV-7

HEAT VALUE
(BTU Content As Received Basis)
1974

Estimate of Tonnages Remaining

Range/ Field	Less than 12,000	12,000 to 12,500	12,500 to 13,000	More than 13,000
Northern	253,000,000	428,000,000	797,000,000	466,000,000
Eastern Middle	63,000,000	74,000,000	108,000,000	30,000,000
Western Middle	152,000,000	610,000,000	1,311,000,000	975,000,000
Southern	2,308,000,000	3,888,000,000	4,982,000,000	972,000,000

Source: Prepared by Consultant based on data from U. S. Bureau of Mines Technical Paper 659, 1944.

TABLE IV-8

VOLATILE MATTER
(Percentage)
1974

Estimate of Tonnages Remaining

Range/ Field	Under 4%	4% to 6%	6% to 8%	Over 8%
Northern		699,800,000	1,166,000,000	78,000,000
Eastern Middle	193,000,000	82,000,000		
Western Middle	152,000,000	2,530,000,000	91,000,000	274,000,000
Southern	1,215,000,000	6,440,000,000	851,000,000	3,645,000,000

Source: Prepared by Consultant based on data from:

G. F. Deasy, and P. R. Griess, Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite, The Pennsylvania State University, Bulletin of the Mineral Industries Experimental Station, Number 80, 1963.

TABLE IV-9

SULPHUR
(Percentage)
1974

Estimate of Tonnages Remaining

Range/ Field	Under .55	.55 to .75	Over .75
Northern	233,000,000	1,089,000,000	622,000,000
Eastern Middle	220,000,000	55,000,000	
Western Middle	457,000,000	1,890,000,000	701,000,000
Southern	4,010,000,000	7,534,000,000	608,000,000

Source: Prepared by Consultant based on data from:

G. F. Deasy, and P. R. Griess, Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite, The Pennsylvania State University, Bulletin of the Mineral Industries Experimental Station, Number 80, 1963.

E. WATER IN THE ANTHRACITE FIELDS

E.1 Static Mine Pools

One of the most critical problems in the Pennsylvania anthracite industry is removing the water which has collected in the abandoned mines. In addition, the surface water which enters the mines through infiltration has to be pumped to the surface or drained by gravity through drainage tunnels.

During the period from 1945 to 1948 the Bureau of Mines made an in-depth study of the mine pools in each of the fields.[1] This study utilized all available mine maps and cross sections to determine the number of pools in each field and the volume of water in each pool. The altitude of the overflow points and the directions of flow between the pools were also located. This was the last exhaustive study wherein an estimate of the water impounded in the pools was made. Since that time only the levels of the pools have been measured and estimates or measurements of the flow at outfalls have been made.[2]

Data on the mine pools at the completion of the 1949 study is contained in Table IV-10.

TABLE IV-10

DATA ON ANTHRACITE MINE POOLS[1]

Pennsylvania Anthracite Region
1949

Field	Number of Pools	Volume of Water Gallons
Northern	39	16,000,000,000
Eastern Middle	31	4,000,000,000
Western Middle	58	38,000,000,000
Southern	31	31,500,000,000

---

[1]S. H. Ash, and others, Water Pools in Pennsylvania Anthracite Mines, U. S. Bureau of Mines, Technical Paper 727, 1949.

[2]Interview with U. S. Bureau of Mines' personnel in Schuylkill Haven, Pennsylvania.

Since the completion of the study in 1949 a large number of mines have ceased operations. As a result, either new pools have formed or there have been considerable rises in the altitudes of some of the existing pools.

The Bureau of Mines now lists 46 mine pools in the Southern Field as opposed to 31 pools in 1949.[1] In the Western Middle Field there are now 67 pools and a number of the original pools have risen considerably in elevation. There has been no new data collected on the Eastern Middle Field; however, it is probable that there is not too much difference between the water pool conditions in 1949 and the present because of the system of gravity drainage tunnels in this field. In the Wyoming and Lackawanna Basins of the Northern Field all the mines are connected to some degree by known openings or breaches in the barrier pillars between the mines. The result of this is that the mine pool is continuous over the entire field and contains considerably more water than it did in 1949.

As a part of this study, an estimate of the quantity of water impounded in each of the fields was made. This task was made difficult by the lack of or inconsistency of information. For example, the 1949 study included all known mine pools except those in the Southern Field located east of Tamaqua, since the operating companies in that locale wished to keep the data on their mines confidential. Thus there is no base data from that area on which to make a prediction of the water in the pools at this time.

The computations to estimate the water presently impounded in the Eastern Middle, Southern and Western Middle Fields were based on the assumption that the cross sections of the individual pools would be either triangular or, in some areas, rectangular and that the increase in water volume would vary with the surface elevation of the pool. The results of these calculations are shown in Tables IV-11, IV-12 and IV-13. The water volumes of the Eastern Middle, Southern and Western Middle Fields are estimated at 14 billion gallons, 38 billion gallons and 61 billion gallons, respectively. The continuous power required to lower, in twelve months, the static pools of these fields to the levels of their former lowest workings is approximately 1,300 kilowatts, 11,700 kilowatts and 13,800 kilowatts, respectively.

A somewhat different approach was used to calculate the volume of water in the Northern Field, principally because of the complete inundation of the field and the continuity of the mine pool. It was assumed that the void space left by the mining is now filled with water and that the volume of water could be determined from the deep mine production which has taken place below the mine pool surface. This method was chosen after discussion with U. S. Bureau of Mines personnel in Wilkes-Barre, Pennsylvania, and further research of the water conditions in the Northern Field.

---

[1] Ibid.

TABLE IV-11

ESTIMATE OF VOLUME OF MINE POOLS AND KILOWATTS OF POWER REQUIRED FOR DEWATERING

Eastern Middle Field
1974

Mine Name	Level	Head (feet)	Volume Gals.x10^9	Power Required for Pumping*(Kilowatts) VF-500	500-1,000
McCauley Mountain Basin	VF-500	84	0.051	2	
Gowen #16 Slope	VF-500	140	0.248	18	
Coxe-Gowen	VF-500	126	0.277	18	
Coxe-Deringer	VF-500	109	0.346	19	
Black Ridge	VF-500	47	0.160	4	
West Woodside Basin	VF-500	41	0.068	2	
East Woodside Basin	VF-500	74	0.085	4	
Upper Lehigh West Basin	VF-500	47	0.426	11	
Upper Lehigh East Basin	VF-500	39	0.026	1	
Highland #6	VF-500	46	0.243	6	
Pond Creek	VF-500	46	0.095	3	
Harleigh	VF-500	103	0.007	1	
Jeddo #7, Fishtail Slope	VF-500	42	0.026	1	
Cranberry #8, Slope Basin	VF-500	161	1.333	110	
Harwood South Basin	VF-500	197	0.262	26	
Harwood Back Basin	VF-500	53	0.054	2	
Cranberry #11 Plane Basin	VF-500	164	0.660	55	
Hazleton Basin	VF-500	167	0.266	23	
	500-1,000	644	0.073		24
Diamond Basin	VF-500	167	0.872	75	
	500-1,000	644	0.236		78
Stockton Basin	VF-500	167	1.934	165	
	500-1,000	667	0.539		184
Hazle Brook	VF-500	128	0.481	32	
Buck Mountain Strip	VF-500	14	0.012	1	
Audenreid	VF-500	200	1.050	108	
Spring Brook	VF-500	183	1.390	130	
Tresckow	VF-500	213	0.342	37	
Tresckow #21 Slope	VF-500	150	0.531	41	
Spring Mountain	VF-500	176	0.397	36	
Coleraine	VF-500	180	0.331	31	
Evans	VF-500	125	0.097	6	
Silver Brook	VF-500	172	0.957	84	
				1,052	286

* Continuous power required to lower the static pools to the levels of their former lowest workings in a period of twelve months for each increment of 500 feet.

Source: Prepared by Consultant based on data from U. S. Bureau of Mines Technical Paper 727, 1949.

TABLE IV-12

ESTIMATE OF VOLUME OF MINE POOLS AND KILOWATTS OF POWER REQUIRED FOR DEWATERING

Southern Field
1974

Mine Name	Level	Head (feet)	Volume Gals.x10^9	Power Required for Pumping* (Kilowatts)			
				VF-500	500-1,000	1,000-1,500	1,500-2,000
Tamaqua S.D.	VF-500	140.0	0.800	57			
Tamaqua N.D.	VF-500	264.0	0.312	42			
Mary C.	VF-500	306.0	0.400	63			
Kaska	VF-500	304.5	0.372	58			
	500-1,000	750.0	0.216		83		
	1,000-1,500	1,050.0	0.012			7	
Silver Creek	VF-500	318.3	0.852	139			
	500-1,000	691.5	0.922		327		
Eagle Hill	VF-500	317.8	0.284	46			
	500-1,000	750.0	0.393		151		
	1,000-1,500	1,024.7	0.051			27	
Palmer Vein	VF-500	354.3	0.200	36			
	500-1,000	651.6	0.200		67		
Bear Ridge	VF-500	278.0	0.040	6			
Pine Forest	VF-500	393.0	0.419	84			
Wadesville	VF-500	294.6	2.185	330			
	500-1,000	628.1	1.397		449		
Pottsville East	VF-500	262.7	0.038	5			
	500-1,000	750.0	0.040		15		
	1,000-1,500	1,250.0	0.040			26	
	1,500-2,000	1,538.7	0.006				5
Pine Knot No.1	VF-500	344.5	0.656	115			
	500-1,000	580.3	0.154		46		
Thomaston	VF-500	330.5	0.423	72			
	500-1,000	552.3	0.361		102		
Richardson	VF-500	330.5	0.337	57			
	500-1,000	552.3	0.287		81		
Glendower	VF-500	400.0	0.609	124			
	500-1,000	645.0	0.518		171		
Buck Run (Old)	500,1,000	637.0	0.477		156		
Bun Run (Dam Basin)	VF-500	208.0	0.053	6			
Lytle	VF-500	387.5	1.821	360			
	500-1,000	750.0	2.815		1,078		
	1,000-1,500	1,165.0	0.883			525	
Phoenix Park	VF-500	403.5	0.904	187			
	500-1,000	750.0	1.140		438		
	1,000-1,500	1,017.3	0.010			51	
Otto	VF-500	500.0	1.332	341			
	500-1,000	750.0	0.879		338		
	1,000-1,500	1,052.5	0.053			29	
Middle Creek	VF-500	250.0	0.608	78			
	500-1,000	594.9	0.092		28		
Blackwood	VF-500	295.3	0.035	5			
Colket	VF-500	296.0	0.513	78			
Good Spring No.3	VF-500	311.0	0.396	63			
	500-1,000	584.0	0.075		23		
Good Spring No.1	VF-500	379.0	0.512	99			
	500-1,000	660.0	0.403		136		
Westwood	VF-500	348.0	0.162	29			
	500-1,000	653.0	0.091		31		
New Lincoln	VF-500	392.5	0.077	15			
	500-1,000	660.0	0.068		230		
R. Creek and New Franklin	VF-500	250.0	0.836	107			
	500-1,000	592.5	0.053		16		
Lincoln	VF-500	450.5	0.407	94			
	500-1,000	750.0	1.337		513		
	1,000-1,500	1,097.7	0.194			109	
Brookside	500-1,000	752.0	0.739	284			
	1,000-1,500	1,250.0	0.739		473		
	1,500-2,000	1,659.0	0.467			396	
Williamstown	VF-500	355.0	1.246	226			
Lykens	500-1,000	750.0	2.199		844		
	1,000-1,500	1,250.0	2.199			1,407	
	1,500-2,000	1,701.5	1.759				1,532
				2,593	4,974	2,570	1,537

*Continuous power required to lower the static pools to the levels of their lowest former workings in a period of twelve months for each increment of 500 feet.

Source: Prepared by Consultant based on data from U. S. Bureau of Mines Technical Paper 727, 1949.

TABLE IV-13

ESTIMATE OF VOLUME OF MINE POOLS AND KILOWATTS OF POWER REQUIRED FOR DEWATERING

Western Middle Field
1974

Mine Name	Level	Head (feet)	Volume Gals.x10^9	Power Required for Pumping**(Kilowatts) VF-500	500-1,000	1,000-1,500	1,500-2,000
North Franklin	VF-500	279.5	1.503	214			
	500-1,000	536.7	0.062		17		
Bear Valley	VF-500	355.0	1.117	203			
	500-1,000	563.0	0.207		59		
Glen Burn	VF-500	443.0	0.431	98			
	500-1,000	750.0	1.323		506		
	1,000-1,500	1,154.3	0.398			234	
Cameron			*				
Neilson	VF-500	257.0	0.027	4			
	500-1,000	750.0	0.013		5		
	1,000-1,500	1,073.0	0.001			1	
Henry Clay	VF-500	285.0	1.091	159			
	500-1,000	610.3	0.254		79		
Stirling	VF-500	285.0	1.264	184			
	500-1,000	563.7	0.132		38		
Burnside	VF-500	313.0	0.979	156			
	500-1,000	574.0	0.157		46		
Luke Fidler	VF-500	315.5	0.337	54			
	500-1,000	750.0	0.306		117		
	1,000-1,500	1,250.0	0.133			85	
	1,500-2,000	1,544.3	0.006				5
Royal Oak	VF-500	199.3	0.097	10			
Buck Ridge No.2			*				
Main Slope	VF-500	311.0	0.162	26			
	500-1,000	563.0	0.020		6		
No.7 Slope	VF-500	28.0	0.010	0.2			
No.4 Slope	VF-500	30.0	0.021	0.3			
Water Tunnel	VF-500	94.3	0.024	1			
Greenback			*				
Buck Ridge No.1	VF-500	361.0	0.178	33			
	500-1,000	653.0	0.113		37		
Big Mountain	VF-500	250.0	0.824	105			
	500-1,000	517.3	0.007		2		
Hickory Swamp	VF-500	424.5	0.115	25			
	500-1,000	558.3	0.046		13		
Colbert	VF-500	390.5	0.153	30			
	500-1,000	600.0	0.077		23		
Corbin	VF-500	294.5	0.331	50			
	500-1,000	546.7	0.023		6		
Excelsior	VF-500	287.0	1.288	189			
	500-1,000	529.7	0.040		11		
Enterprise			*				
Natalie	VF-500	343.5	0.952	167			
	500-1,000	540.7	0.081		22		
Hickory Ridge	VF-500	495.0	0.037	9			
	500-1,000	511.3	0.055		14		
Scott Ridge			*				
Scott	VF-500	283.0	0.957	138			
	500-1,000	750.0	0.494		189		
	1,000-1,500	1,043.0	0.022			12	
Richards Water Level	VF-500	297.0	0.118	18			
	500-1,000	504.7	0.0001		1		
Greenough	VF-500	364.0	0.205	38			
	500-1,000	615.0	0.093		29		
Richards Shaft	VF-500	295.0	1.123	169			
	500-1,000	750.0	0.498		190		
	1,000-1,500	1,003.3	0.0002			1	
Pennsylvania	VF-500	324.0	1.698	281			
	500-1,000	750.0	1.023		392		
	1,000-1,500	1,021.3	0.013			7	
Sayre-Sioux	VF-500	336.5	1.664	285			
	500-1,000	531.7	0.089		24		
Reliance			*				
Alaska			*				
Locust Gap			*				
Mid Valley No.1 and No.2	VF-500	331.0	0.275	46			
	500-1,000	576.0	0.056		16		

TABLE IV-13 (CONTINUED)

ESTIMATE OF VOLUME OF MINE POOLS AND KILOWATTS OF POWER REQUIRED FOR DEWATERING

Western Middle Field
1974

Mine Name	Level	Head (feet)	Volume Gals.x10^9	Power Required for Pumping** (Kilowatts) VF-500	500-1,000	1,000-1,500	1,500-2,000
Mid Valley No.3	VF-500	419.0	0.077	16			
	500-1,000	596.7	0.054		16		
Centralia			*				
	500-1,000	629.3	0.301	97			
Germantown-Pottsville	VF-500	346.0	0.027	5			
	500-1,000	750.0	0.022		9		
	1,000-1,500	1,056.3	0.002			1	
Continental East	VF-500	376.5	2.510	482			
	500-1,000	750.0	2.587		991		
	1,000-1,500	1,046.0	0.127			67	
Tunnel	VF-500	290.5	0.457	68			
	500-1,000	649.7	0.167		55		
Preston No.3	VF-500	302.0	0.553	85			
	500-1,000	542.7	0.035		10		
Raven Run	VF-500	320.0	0.193	32			
	500-1,000	506.7	0.001		1		
Hammond			*				
Packer No.5			*				
Girard	VF-500	287.5	0.855	126			
	500-1,000	544.3	0.051		14		
West Bear Ridge	VF-500	281.0	0.708	102			
	500-1,000	602.7	0.145		45		
Weston (Packer No.2, 3 and 4)			*				
Draper			*				
East Bear Ridge	VF-500	168.3	0.428	37			
Lawrence	VF-500	272.0	2.097	291			
	500-1,000	750.0	0.817		313		
	1,000-1,500	1,148.3	0.0003			1	
Kehley Run	VF-500	396.0	0.600	121			
	500-1,000	516.0	0.022		6		
Kohinoor-West Shenandoah	VF-500	307.0	1.062	166			
	500-1,000	630.3	0.360		116		
Gilberton	VF-500	261.0	1.543	206			
	500-1,000	750.0	0.777		298		
	1,000-1,500	1,068.0	0.071			39	
Indian Ridge	VF-500	338.5	1.645	284			
	500-1,000	508.3	0.008		2		
Shenandoah City	VF-500	360.5	0.646	119			
	500-1,000	613.3	0.279		87		
Maple Hill	VF-500	380.0	2.374	460			
	500-1,000	750.0	2.699		1,033		
	1,000-1,500	1,065.0	0.230			125	
Maple Hill East	VF-500	380.0	1.245	241			
	500-1,000	617.3	0.680		214		
St. Nicholas	VF-500	277.0	1.095	154			
	500-1,000	750.0	0.473		181		
	1,000-1,500	1,015.7	0.003			2	
Boston Run	VF-500	265.5	0.632	86			
	500-1,000	750.0	0.315		120		
	1,000-1,500	1,056.6	0.023			13	
Knickerbocker	VF-500	347.5	2.027	360			
	500-1,000	594.7	0.614		186		
North Mahanoy	VF-500	355.0	0.525	95			
	500-1,000	592.3	0.164		50		
Mahanoy City	VF-500	322.0	1.633	268			
	500-1,000	604.0	0.455		140		
Tunnel Ridge	VF-500	333.5	0.846	144			
	500-1,000	609.7	0.392		122		
Park No.1 & 2 and Springdale	VF-500	163.0	0.575	48			
Primrose	VF-500	380.0	0.437	85			
	500-1,000	501.7	0.0002		1		
Park No.3 & 4			*				
Vulcan Buck Mountain	VF-500	410.5	1.028	216			
	500-1,000	633.3	0.939		303		
Morea New Boston			*				
William Penn			*				
				7,088	6,155	589	5

* Indicates no pool volume data available.
** Continuous power required to lower the static pools to the levels of their former lowest workings in a period of twelve months for each increment of 500 feet.

Source: Prepared by Consultant based on data from U. S. Bureau of Mines Technical Paper 727, 1949.

The computation for the water volume in the Northern Field is as follows:

Deep Mine Production to date	3.7 billion tons
Estimated Amount Below Pool Surface	3.5 billion tons

In-place volume of one ton of coal = 25 c.f. (This factor takes into account normal overbreakage)

Volume occupied by deep mined coal = (3.5) (25) = 87.5 billion c.f.

$$(87.5 \text{ billion c.f.}) \left(7.48 \frac{\text{gals.}}{\text{c.f.}}\right) = 654.5 \text{ billion gallons}$$

it is stated in Technical Paper 727, Water Pools in Anthracite Mines:

> Where mines have been flooded to extinguish mine fires or abandoned mines have been unwatered the mining records show that the volume of water contained in the mine workings was 40 percent of the total original volume of the mine workings that had been flooded whether the area had been first-mined, robbed, or hand-packed. The figure of 40 percent is conservative, errs on the safe side and was employed to determine the quantity of water impounded in all underground water pools in all fields.

Subsidence is another factor which would cause a reduction in the volume left after extraction of the coal, thereby reducing the amount of water contained in the mine voids. It was assumed that the loss in water volume due to subsidence is accounted for in the 40 percent reduction factor.

Thus assuming a modification factor of 40%:

Northern Field Pool Volume = 0.4(654.5) = 261.8 billion gallons

In order to determine an approximate cost to dewater the field, the pool is assumed to have the following distribution below the valley floor and would have to be pumped against the head listed:

Depth	Distribution Factor	Volume	Average Static Head	Power Requirement
VF-500	50%	131 billion gallons	250 feet	16,800 kw
500-1,000	40%	104 billion gallons	750 feet	40,000 kw
1,000-1,500	10%	26 billion gallons	1,250 feet	16,600 kw

E.2 Infiltrating Water

In addition to the water contained in the abandoned workings the infiltrating water resulting from rainstorms, etc., must also be pumped from the mines. In Technical Paper 727, of the U. S. Bureau of Mines, "Water Pools in Pennsylvania Anthracite Mines", the following statement is made with regard to infiltration:

> The volume of water entering into mine workings during and after any period of precipitation varies greatly in adjoining basins, and even in adjoining collieries in the same field, because of differences in the condition of the strata as affected by the progress of the extraction of the anthracite, particularly that from the uppermost beds. The ratio between run-off and infiltration varies for each period of precipitation in any given area because of variables in the rate of precipitation, duration of storm, rate of evaporation that depends upon the temperature and humidity, transpiration dependent on the season and the amount of vegetable life, status of the water table, and so on.
>
> Strippings especially contribute to this infiltration of water because of the removal of overburden and because of the longitudinal extent of strippings along the outcrop of the anthracite beds. Many fissures and cave-ins are not visible on the surface because they are hidden under refuse banks or are partly filled with dirt; nevertheless these openings contribute much to water seepage.

We have estimated the amount of infiltration for each of the fields taking into account the variables in the aforementioned statement. Table IV-14 summarizes the data on the size of the fields and the parameters used for rainfall, evaporation, evapotranspiration and infiltration.

TABLE IV-14

ESTIMATE OF INFILTRATING WATER FOR THE VARIOUS FIELDS

Pennsylvania Anthracite Region

Field	Northern	Eastern Middle	Western Middle	Southern
Total Area (Acres)	112,640	21,120	60,160	115,840
Strip Mine Area (Acres)	33,920	8,960	30,080	28,800
Watershed Area (Acres)	78,720	12,160	30,080	87,040
Maximum Annual Rainfall	54"	61"	61"	56"
Evaporation (Strip Mines)	24"	24"	24"	24"
Evapotranspiration (Watershed)	28"	28"	28"	28"
Percent Infiltration (Strip Mine Areas)	90	90	90	90
Percent Infiltration (Watershed)	60	60	60	60
Total Infiltration (Million gallons/year)	58,211	14,639	37,244	72,834

Source: Prepared by Consultant.

Over the years the records show that the number of tons of water pumped per ton of coal produced has varied greatly. During the infancy of the industry the ratio of tons of water pumped to tonnage of coal produced was ten or less. During the period from 1944 to 1948 the average ratio for the entire Anthracite Region was 19. In 1960, the average ratio of tons of water pumped per ton of coal produced, based on data from 30 reporting inspection districts, was 78 and in 1970 there were 13 reporting districts and the average ratio was 81. The maximum for any one district in 1960 was 513 and in 1970 it was 831. The lowest ratio reported for either period was 2.3.

At the time of the 1949 study, to accumulate data on the underground pools, an investigation was made to collect data on the water contained in abandoned strip mines. As a result, an incomplete list of 141 water filled abandoned strip mines was compiled. The pools tabulated are those which are considered permanent and are not connected with any underground mine pools. The volume of water contained in these pools at the time of the investigation was 2.3 billion gallons.

Almost all the coal which will be removed by future deep mining and that which will be extracted from deep strip mines will require pumping to maintain the working areas.

E.3 Cost of Pumping

Historically, the handling of water in the anthracite mines has been a costly operation. The capital expenditure to install the pumps is high and the operating costs can be extremely high depending on the periods of pump operation.

Using the data on the mine pools as discussed in Section E.1 and contained in Tables IV-11, IV-12, and IV-13, and the figures for the infiltration from Table IV-14, the cost of completely dewatering the four anthracite fields has been estimated using today's rates for power use. It has been assumed that the pumping would be continuous over a one year period in order to arrive at a mean flow rate. The pumping head was determined assuming that the water would be pumped to the surface from each increment of 500 feet below the surface. All of these numbers were then used in the basic horsepower equation, $Hp = \gamma^{HQ}/550e$, which has been modified by appropriate conversion factors and a pump efficiency factor of 70 percent to determine power requirements in kilowatts. The resulting equation is:

$P = 0.512\ HV$

H = Static Head

V = Volume of water to be pumped expressed in billions of gallons

The cost to carry out the pumping operation is based on rate schedule LP-3 published by the Pennsylvania Power & Light Company and dated January 10, 1974.

Table IV-15 is a summary of the power costs to dewater all the fields. The table shows the power cost of lowering the static head and the power cost to maintain the pool at the lower level.

TABLE IV-15

SUMMARY OF ESTIMATED COSTS TO DEWATER AND MAINTAIN MINE POOLS AT LOWER LEVELS

All Fields
1974
(Costs in Dollars per Month)

	Northern	Eastern Middle	Western Middle	Southern
STATIC POOL*				
VF-500**	$152,000	$12,000	$65,000	$ 28,000
500-1,000	360,000	4,000	57,000	54,000
1,000-1,500	150,000		7,000	25,000
1,500-2,000				16,000
INFILTRATION	$ 69,000	$ 7,000	$53,000	$109,000

*Based on operating for 12 months to reduce the pool by each 500 foot increment.
**VF = Valley Floor.

Source: Prepared by Consultant.

The cost for pumping the infiltrating water is constant since it was assumed that this water would be pumped from the highest possible pumping level; that is, a point half way between the original static pool and a depth of 500 feet. The above costs are only for operating the pumps.

F. RELATIONSHIP OF RESERVES TO FUTURE DEMAND

The compilations of the resources for the Southern and Western Middle Fields show that the coal required to meet the future demand, as presented in Chapter III, can be extracted from one of several quadrangles in either the Western Middle or Southern Fields. Limiting the development of future mining to a specific area in lieu of scattered operations throughout the fields would be more systematic and the cost of pumping, treatment and preparation would be reduced.

An example of a locale in the Southern Field where the market demand for coal would be met, and the cost of pumping would be low, is a portion of the Minersville synclinorium. This is located between the town of Tremont and Minersville Borough in the Minersville quadrangle. This is an area of 20 square miles which is underlain by an estimated two billion tons of coal. Plates IV-16 and IV-17 show the structural cross-section of the Minersville synclinorium.

Plate III-2 identified the additional production that would be required to supply the cumulative increase in demand to the year 1990. The additional 57 million cumulative tons can be extracted from this area while achieving a reduction in pumping, treatment and preparation costs. Plate IV-18 shows the depth required to capture the cumulative demand in the years 1985, 1990 and 2000. A mining recovery factor of 50 percent was assumed in determining the depth. The consultant then estimated the amount of water and the associated pumping costs to drain the water to these prescribed depths.

There are five major mine pools here containing approximately 10.5 billion gallons of water, and it is estimated that another eight billion gallons per year enters the mines through infiltration. Table IV-16 shows the cost to pump the water from this area from the various levels below the surface.

TABLE IV-16

PUMPING COST IN A PORTION OF THE MINERSVILLE SYNCLINORIUM

1974

Depth	Cost to Lower Static Pool	Cost to Pump Infiltrating Water	Total Pumping Cost
VF-500	$ 8,000/month	$16,000/month	$24,000/month
500-1,000	$17,000/month	$16,000/month	$33,000/month
1,000-1,500	$ 5,000/month	$16,000/month	$21,000/month

Source: Prepared by Consultant.

The costs computed are based on continuous pumping to dewater each level of 500 feet in a period of one year and do not include the capital costs for the pumps, their installation, labor or maintenance costs.

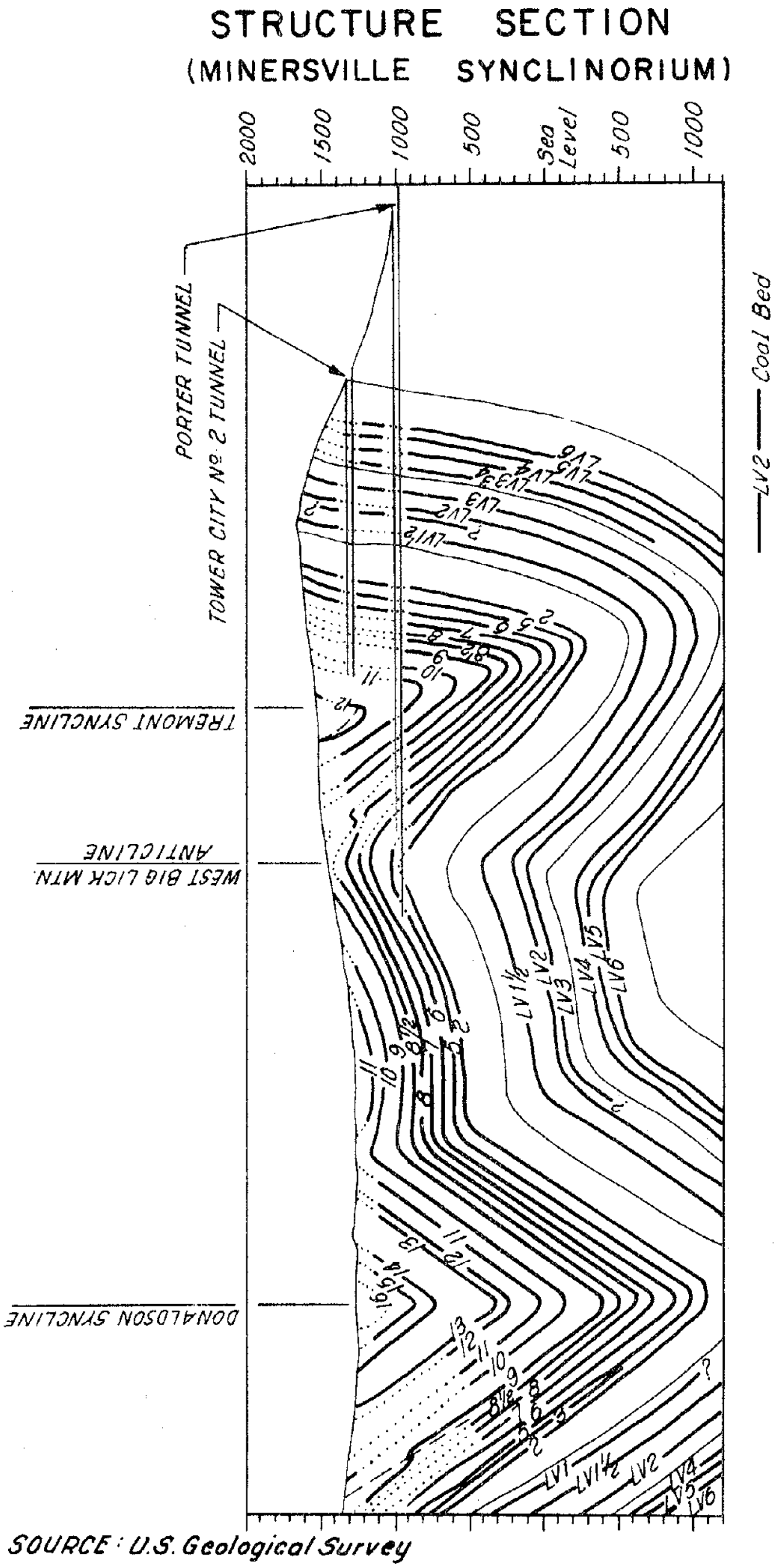
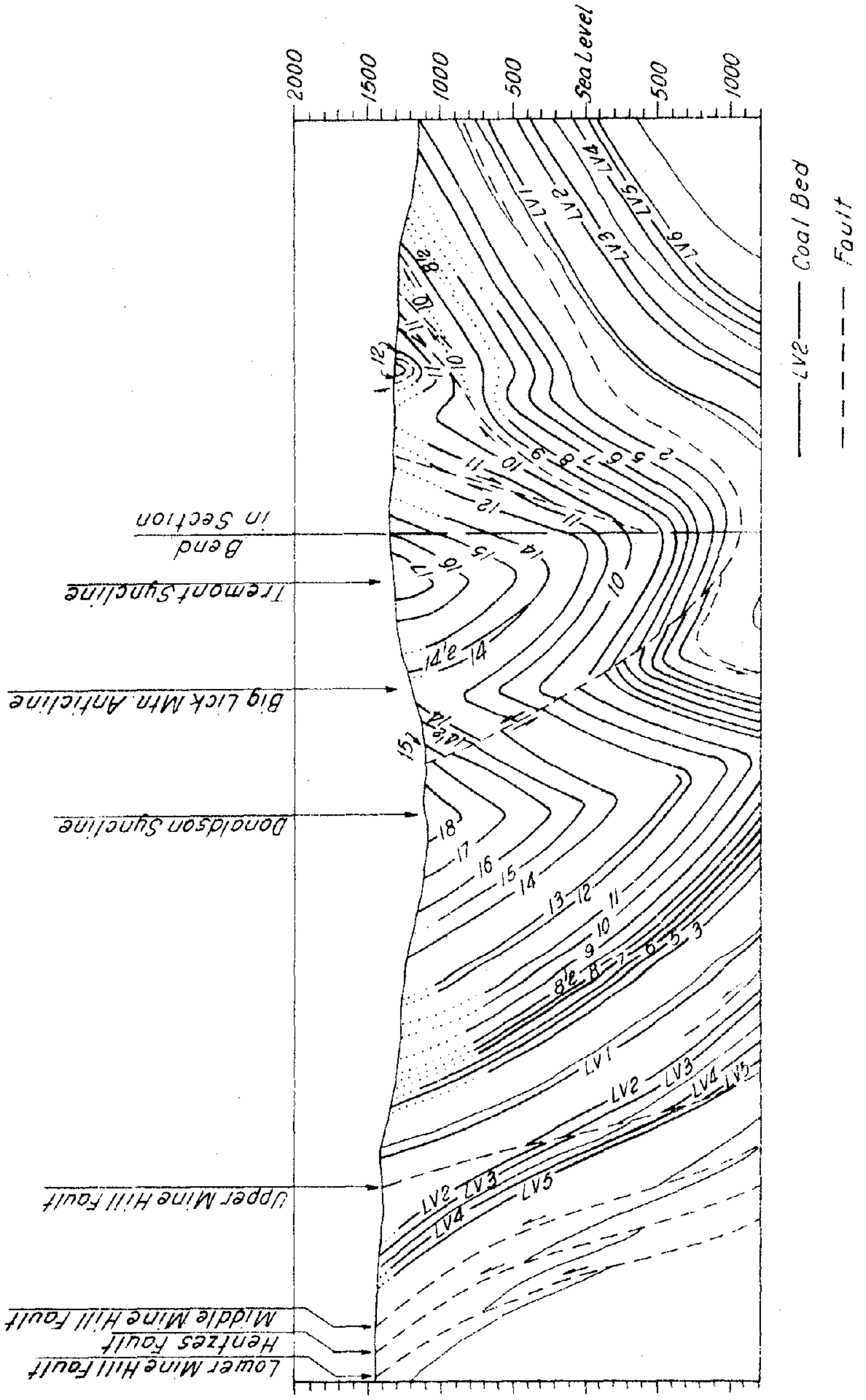

STRUCTURE SECTION
(MINERSVILLE SYNCLINORIUM)
2000
1500
1000
500
Sea Level
500
1000
PORTER TUNNEL
TOWER CITY No. 2 TUNNEL
TREMONT SYNCLINE
WEST BIG LICK MTN. ANTICLINE
DONALDSON SYNCLINE
LV2 —— Coal Bed
SOURCE: U.S. Geological Survey

PLATE IV - 16

STRUCTURE SECTION
(MINERSVILLE SYNCLINORIUM -CONT'D.)



SOURCE: U.S. Geological Survey

PLACE IV - 17

DEPTH vs. CUMULATIVE TONNAGE
MINERSVILLE SYNCLINORIUM

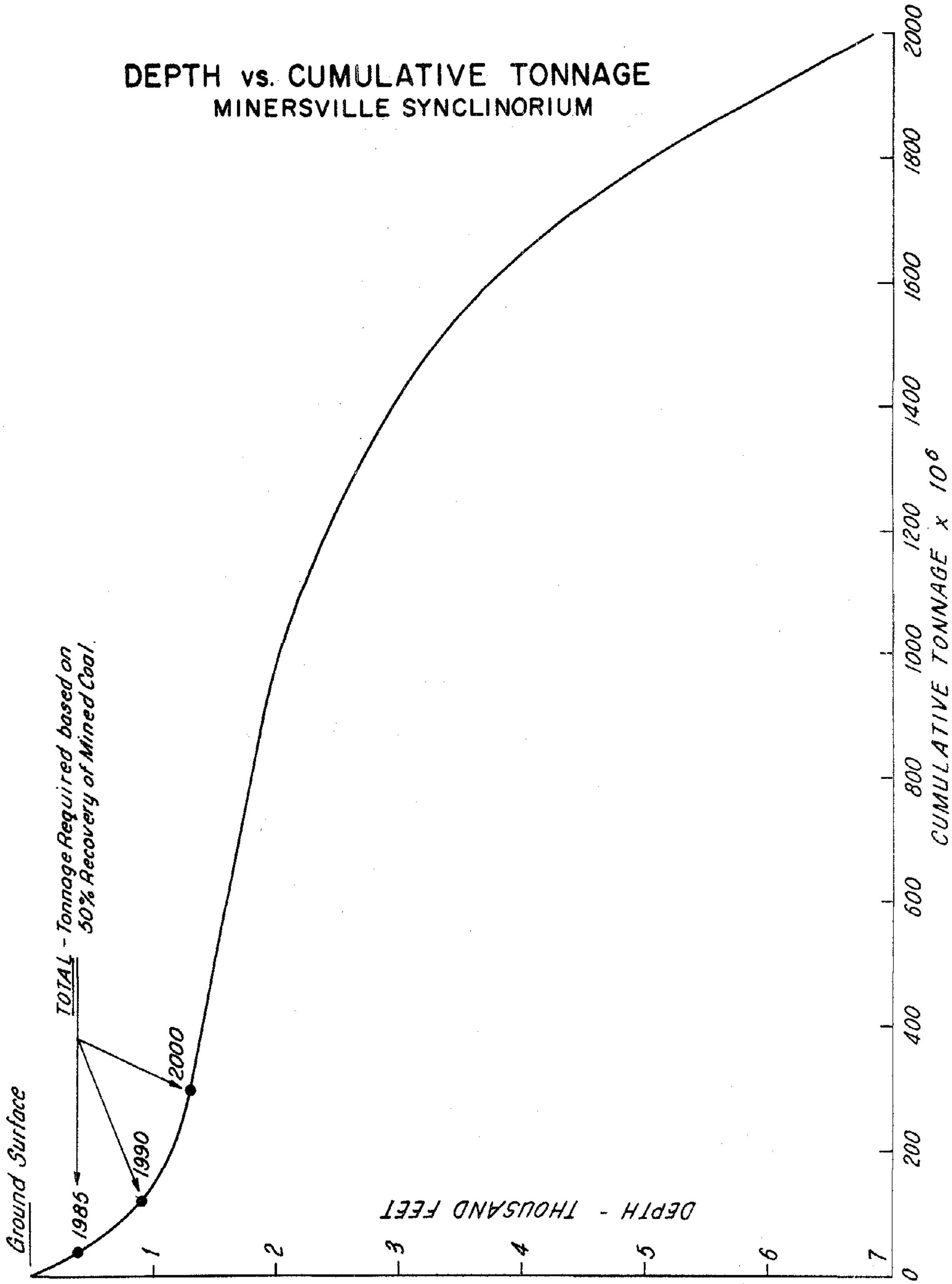


PLATE IV - 18

In addition to the pumping cost, the cost figure to treat the water before discharging it to the streams would be approximately $0.25 to $0.35 per 1,000 gallons of water treated and includes both capital and operating costs. The treatment process considered is a centralized hydrated lime system.

BUCK MOUNTAIN BED AT PACKER NO.1-5 COLLIERY
1907

From the Collection of the Smithsonian Institution

CHAPTER V - SUMMARY

TECHNOLOGICAL EVALUATION FOR RESEARCH AND DEVELOPMENT REQUIREMENTS

Surface mining methods in anthracite have successfully adapted the larger excavators (up to 85 cubic yard capacity) for overburden removal. Even these machines are, however, restricted to a limited economical depth. Except for some basin surface mining, stripping with present equipment is confined to about 150 foot depth.

The past attempts at anthracite deep mine mechanization are reviewed with respect to advantages, limitations and conclusions. These tests have shown that anthracite coal can be extracted mechanically at a rate which exceeds conventional hand mining. In most cases, only a specific piece of equipment was tested. Exhaustive tests were not always possible due to mine abandonment, severe water problems in the Northern Field, or other factors. None of these developments, however, has been adopted by the declining industry, except for a limited use of longhole mining. In the Northern Field one company did use continuous miners profitably for a time until severe water problems forced closure of the mine. However, this was room and pillar mining on moderate pitches, similar to bituminous mining, and so not typical to anthracite mining.

"New" coal, that is, from sources other than those being currently worked, is projected to total 147 million tons by 2000 and 237 million tons by 2010. Three scenarios are presented, the first postulating that all new production is conventional surface mining; the second, all deep pit mining; and the third, all deep mining.

There are sufficient reserves of strippable coal (that is, within 150 feet of the surface) to provide projected needs through 2000. Research is recommended on methods to improve fragmentation of sandstone and conglomerate overburden in order to facilitate loading by the smaller (e.g. eight cubic yard) draglines. Government programs to backfill abandoned strip mines should be coordinated to reduce flow to deep mines and to abate acid mine drainage. Development is needed of an economical method to protect trailing cables on electrified equipment. Financial assistance for large equipment purchases is desirable.

It appears that the technology exists to mine to depths of 2000 feet. The problems to be resolved are mostly economic, sociological, ecological and legal. Recommended are: a program of deep drilling to prove out the coal reserves; research in rock mechanics to stabilize pit walls; and a study as to how to solve the water problem. The feasibility of mining to these depths is currently being studied by The Pennsylvania State University.

There is domestic and foreign equipment commercially available which could be adapted for the deep mining of anthracite coal with increased safety, and at a rate which would probably provide the mine operator a greater return. Various types of equipment are discussed for mine development, coal winning, roof support, and transport. The two devices which appear to require the least modification are the roadheader and shearer loader continuous miners.

There are monorail transport systems on the market which will operate in confined spaces and will adapt to anthracite mines with minor modifications.

Research is required to develop a more composite multi-use continuous miner (e.g. a miner-bolter system) which will operate safely in confined spaces. A bi-directional self-advancing hydraulic roof support which will withstand up to 1000 ton loads and maintain its position on at least a 45 degree pitch is essential for the full development of a shearer loader system.

It is not anticipated that deep mining can be revived in the next few years to the extent of providing all the "new" coal requirements. Production figures were projected to show the anticipated mix of deep, strip, and combined culm, refuse and dredge production through 2010. The totals for the 35 year period are 144, 300, and 73 million tons respectively.

A resurgence of deep mining is recommended. This should be encouraged now for two principal reasons, first, to prevent the complete demise of this part of the industry, with the corresponding loss of skills, and, secondly, because strippable reserves will eventually become depleted and surface mining may become much more unacceptable than deep mining for sociological and ecological reasons.

It is recommended that a task force of competent design-mining engineers from industry and government be appointed to evaluate and report on deep mining systems in the United States and overseas. Based on the findings of this group, the adoption of promising components or new design concepts should be considered.

A state-of-the-art mine is recommended to demonstrate that equipment that the Consultant considers the most promising. This joint industry/government effort should test a mechanical mining system with the following as its principal components:

1. Development
   - Road Header (Coal gangways and rock tunnels)
   - Raise Borer (Ventilation Connections)
   - Raise Borer (Shafts and airways)

2. Coal Winning (Short Wall)
   - Shearer Loader Combine

3. Roof Support
   - Self-advancing bi-directional hydraulic chocks.

4. Transportation
   - Monorail

A cost study is included of a deep mine such as the demonstration mine. Based on a 152,000 tpy mine it is estimated that such a mine will break even at a run of mine value of $18 per ton. If, therefore, the price of prepared coal stays above $30 a ton - a good possibility, given the current state of affairs - the mine should return a reasonable profit.

Hydraulic mining is currently undergoing extensive research and development, and a system which will deliver 60,000 psi to the face is being developed. This equipment, when available, should be tested in a complete system of hydraulic mining, transport and hoisting in the state-of-the-art mine.

Because hydraulic mining is in a stage of major development, the cost and production data is not available to fully evaluate its economic feasibility.

CHAPTER V

TECHNOLOGICAL EVALUATION FOR RESEARCH AND DEVELOPMENT REQUIREMENTS

A. OVERVIEW

In the anthracite industry, technological improvements, or the lack of them, are dependent on many factors and constraints which have been discussed in previous Chapters. Failure to modernize methods and equipment can further contribute to the decline of the industry.

Chapter III has identified the potential markets for the rest of this century. These markets are predicated upon a product that is available and competitive. Modernization must occur if anthracite is to compete against its chief rival in the current fossil fuels picture - bituminous coal.

Anthracite deep mining is in the same position regarding mechanization as that experienced by the bituminous industry prior to World War II. It was in the period following the war that bituminous mines were largely mechanized. Anthracite deep mine extraction methods have not improved significantly in 100 years.

Because of the huge reserves, large federal expenditures are now being made to further automate and develop remote control mining procedures in bituminous deep mining. Once these procedures are developed and become fully operational, in perhaps ten years, it will be virtually impossible (if it is not already) for anthracite deep mining to compete.

The strip mining part of the industry has mechanized to some extent, but here again modernization is necessary.

B. PAST AND PRESENT STRIP MINE MECHANIZATION

The quarrying of anthracite along the exposed outcrops was the forerunner of strip mining. One of the earliest attempts occurred at Summit Hill in 1821. The exposures were hand excavated and the material was wheelbarrowed or carted to the nearest dumping site.

The development of the Otis type steam shovel at Pittsburg, Kansas, in 1877, signaled the beginning of mechanization in large scale earth moving activity. The anthracite industry was quick to apply this unique tool to the outcrops found throughout the region. In fact, the first successful mechanical coal stripping was in the anthracite coal fields of Pennsylvania.

The development of the pneumatic drill and the introduction of explosives radically improved the ratio of the overburden that could be moved for each ton of coal won. The development of the churn drill and the dieselization of earth moving equipment further enhanced the strip miner's position. By 1932 strip production had captured seven percent of the market.

The growth of the strip mine industry was constrained by the fact that most coal deposits were controlled by large landholders with sizable investments in deep mine operations. The preservation of crop coal as an effective barrier to inflows of surface water was essential.

The development of the dragline shovel further reduced the cost of strip mined coal and allowed a wider operating range at greater depths. A big increase in strip mining occurred during and following World War II, as large amounts of coal were needed to fuel the war effort. No reclamation of the open pits was required during this period.

The environmental damage resulting from the massive earth moving activity of the past compelled the Commonwealth of Pennsylvania to enact protective legislation designed to arrest environmental pollution. The requirements for reclamation, restoration and mine drainage treatment further discouraged investment in equipment to supply a declining market.

Attempts have been made to increase productive capacity by installing larger and more efficient equipment. The economy of scale has not been sufficient to increase the economic overburden/coal ratio beyond twenty to one. Most small operations find even this ratio unprofitable, and as a consequence, the more easily won seams are mined to shallower depths.

Anthracite strip mine operators today fall into three categories by production: Small - less than 20,000 tons per year, Medium - 20,000 to 50,000 tons per year, and Large - over 50,000 tons per year. Their equipment and methods usually correspond to their size.

Small size strip mine operators (18 in 1973) usually have a straight front shovel or dragline up to the five cubic yard size. Their operations are confined usually to the thinner seams which are worked at shallower depths by removing a minimum of overburden.

Medium size strip mine operators (10 in 1973) usually have equipment (straight front shovel and dragline) ranging in size from five cubic yards to 15 cubic yards. Most of the equipment is diesel powered.

Large size strip mine operators (13 in 1973) usually have equipment (straight front shovel and dragline) starting at the ten cubic yard size and ranging upward. The largest in the region is an 85 cubic yard dragline with a 300 foot boom. Some of the equipment is of the electric powered walker type. Haul trucks have capacities up to 50 or 62 tons and are of the end dump type. Front end loaders, in the six and one-half to ten cubic yard class, are employed where the overburden is suitable. As discussed in Chapter II, these thirteen companies produce the bulk of the current strip mine tonnage.

The hard sandstone overburden over some seams is very hard on equipment. In these cases the dragline is a very durable piece of equipment. One dragline (the first of its class manufactured), purchased in 1938, is still operating. A dragline lasts 75,000 hours or more, whereas a front end loader might last only 15,000 hours. However, their costs are quite different. It also does not mean that the front end loader does not have a use in the anthracite region or that there are not many being used in the region. It does mean that a particular piece of equipment must be suited to the material to be excavated and should be operated in the use for which it was designed.

Total capital value of stripping equipment owned by a large operator may range upwards to $50,000,000.

C. PAST DEEP MINE MECHANIZATION TESTS

In the Pennsylvania anthracite industry the attempt to develop deep mine mechanization is not new. The 1910 Annual Report of the Pennsylvania Department of Mines mentions the increasing use of electricity at the collieries and the development of a coal-cutting machine and electrically-driven drill. Since that time, undercutting machines, conveying equipment and mechanical loaders have been widely used. In the late 1940's, 1950's and early 1960's attempts were made to try different equipment and procedures. According to Mr. Joseph Corgan, retired U. S. Bureau of Mines, some $7,590,000 was spent on these tests between 1952 and 1965, administered by the Schuylkill Haven Anthracite Research Center which was closed in 1965. Other research and development was carried out by the Pennsylvania Coal Research Board.

In considering potential research and development needs in anthracite deep mining, it is necessary to review the past efforts and build on the lessons learned in these tests.

The following is a discussion of the test data extracted from the reports with test conditions, successes, limitations, and conclusions determined during the course of the tests. Almost all of the tests were conducted in the Pennsylvania Anthracite Region. A few are included on steep pitches in other areas. For complete information see the referenced U. S. Bureau of Mines' reports. Plates illustrating the equipment follow most of the descriptions.

C.1 Use of a Continuous Borer[1]

C.1.a General Test Conditions

The average thickness of the coal vein was 30 feet, pitching at 15 degrees to 45 degrees. The work was performed in the Mammoth Vein.

The stratigraphic thickness of the overburden was 555 feet and the average vertical thickness was 650 feet. Overburden consisted of shales, sandstones, and four coal beds which were not of commercial value. Refuse partings in the coal bed were irregular in thickness and position, some varying to three feet in thickness. Crystalline pyritic rock could not be cut with the borer.

The test was conducted at the Germantown Mine, Raven Run Coal Company, Ashland, Pennsylvania starting in February, 1958 and continuing through January, 1960 (361 working days).

The rugged continuous borer was a Goodman Type 420 continuous borer with head thrust of 38,000 pounds. Two side by side rotating cutter units geared together are backed up three feet behind the face by a cutter chain at top and bottom to produce an arch shaped section approximately twelve feet six inches by eight feet.

Maximum speed (per manufacturer) 48 ipm when cutting coal
Maximum speed 26 fpm when tramming
Weight 40 tons including accessory equipment
Required spray water to machine for cooling the bits and wetting the dust made by the cutters

C.1.b Advantages

Higher advance rate and production in gangways than with conventional mining. Gangways could be advanced in any condition encountered when they were kept close to the boundary rock of the bed.

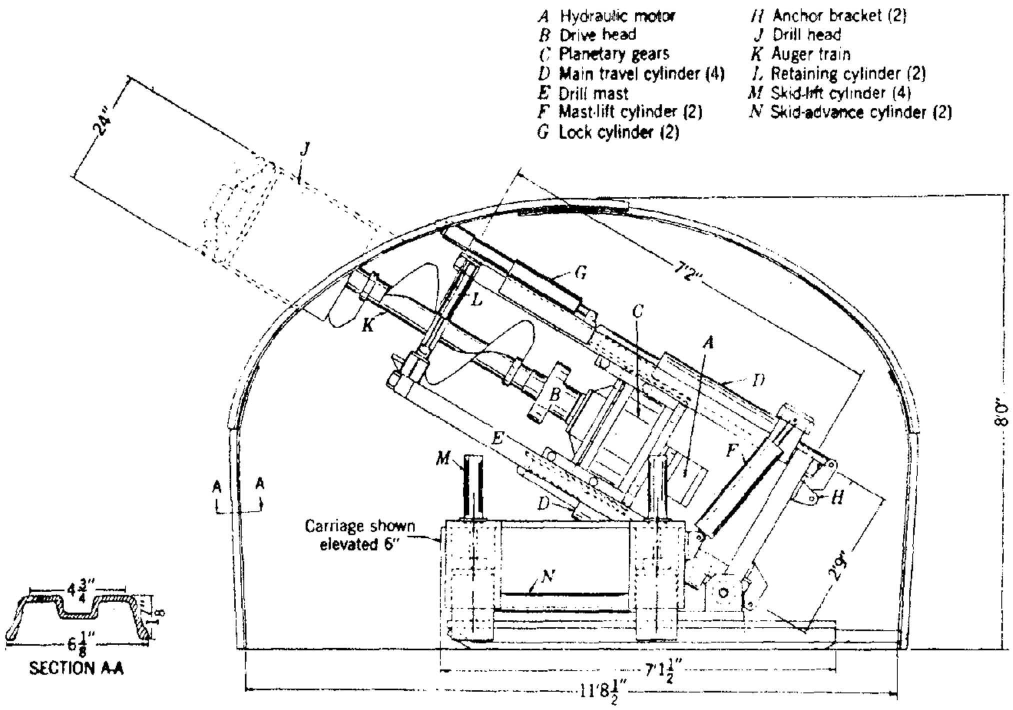
C.1.c Limitations

The continuous borer could not operate on pitches over 27 percent (15 degrees). Since 15 degrees was the lower limit of the pitch of the coal in the test area, its use was limited to driving gangways.

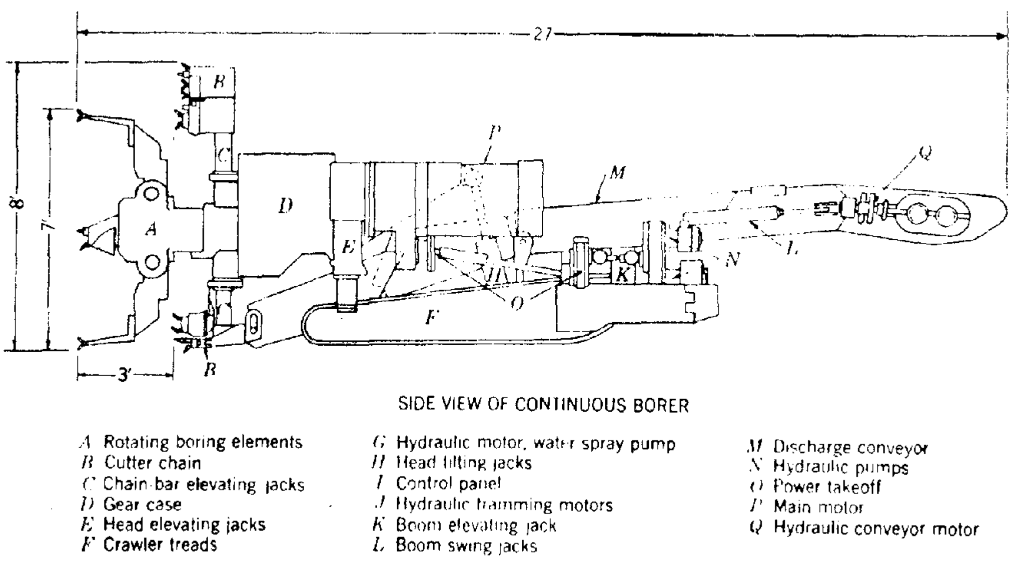
---

[1]W. H. Tavenner and J. T. Schimmel, Use of a Continuous Borer in Mining Pitching Anthracite Beds, U. S. Bureau of Mines, RI 6759, 1966.

CONTINUOUS BORER AND LARGE DIAMETER AUGER



LARGE DIAMETER AUGER



CONTINUOUS BORER

SOURCE: Bureau of Mines Report of Investigations 6135 & 6759

PLATE V - 1

The machine literally filled the work space, causing difficulty in placing heavy-duty timber, placing cushioning material between the timber and the coal rib, and in providing space for the normal expansion of the uncut coal. There was insufficient room to maneuver the machine at the face area, or for removing it rapidly from a completed gangway. The latter problem was caused by convergence in the top, bottom, and sides, requiring enlargement and resupport before removing the borer.

Results fell short of expectations - 18.4 tons per man-day rather than the 30 tons per man-day anticipated. This was due mainly to "other work" averaging 45 percent rather than the 20 percent anticipated. "Other work" included man-days to move the borer from one site to another; retimbering; repairing gangways; installing conveyors, power lines, and service facilities; moving equipment and supplies to the section; and miscellaneous unclassified work. Time studies showed an average advancement of 15.5 feet per seven hour shift in the undisturbed area with a boring rate of four± ipm. Maximum advancement was 50 feet per shift and 87 feet in any three consecutive shifts.

It was determined that driving connecting roads between gangways with the borer was not feasible and primary slope development in the rock below the coal bed was substituted, which in part defeated the objective of eliminating rock work.

In part of the tests some of the gangways driven with the borer crossed a disturbed area, approximately 200 feet wide, where bumping coal and rapid convergence was encountered. Forepoles were driven above the cutting profile when the top was broken. Production was reduced approximately 40 percent in the disturbed area.

The machine operated on a coal floor that was frequently soft because of heaving. The main problem was due to convergence. The lightweight yieldable arches used gave inadequate support to control convergence which in a disturbed area sometimes occurred with explosive violence. This exposed the machine operator to a hazardous condition. Since a satisfactory solution could not be found, the company discontinued the use of a continuous borer.

C.1.d Conclusion

The lightweight yieldable arches used did not control convergence upon removal of the machine. This, along with inadequate roof control and insufficient clearance to maneuver in the face area, reduced the performance of the continuous borer.

The method apparently has potential if the nature of the forces associated with rapid convergence can be better understood and methods are devised to adapt to this problem with safety to all personnel. Other problems to be solved include provision of adequate roof control (which was considerably improved when roof bolts were used in the top rock) provision of clearance to satisfactorily maneuver the machine in the face area and ability to withdraw the machine rapidly. (Average removing time of 50 percent of average advancing time was inordinately high). Perhaps modification of newer machines might overcome these problems.

C.2 Use of a Large Diameter Auger[1]

C.2.a General Test Conditions

The tests were carried out in the Mammoth Vein, averaging 30 feet thick and pitching between 15 degrees and 45 degrees.

The overlying strata averaged 555 feet, consisting of shales, sandstones and four virgin coal beds. Partings in the bed reached a thickness of three feet of soft shale. Crystalline-pyritic rock up to eight inches thick was also encountered. All partings of the bed were penetrated by the auger.

The test was conducted at the Germantown Mine, Raven Run Coal Company, Ashland, Pennsylvania, starting in early 1958 and covering 361 working days. The work coincided with the continuous borer test previously discussed.

As the continuous miner being tested at the same time could operate on pitches up to 15 degrees only, and as there was insufficient maneuvering space to turn it at right angles, the auger was used to drive the necessary ventilation connections between gangways.

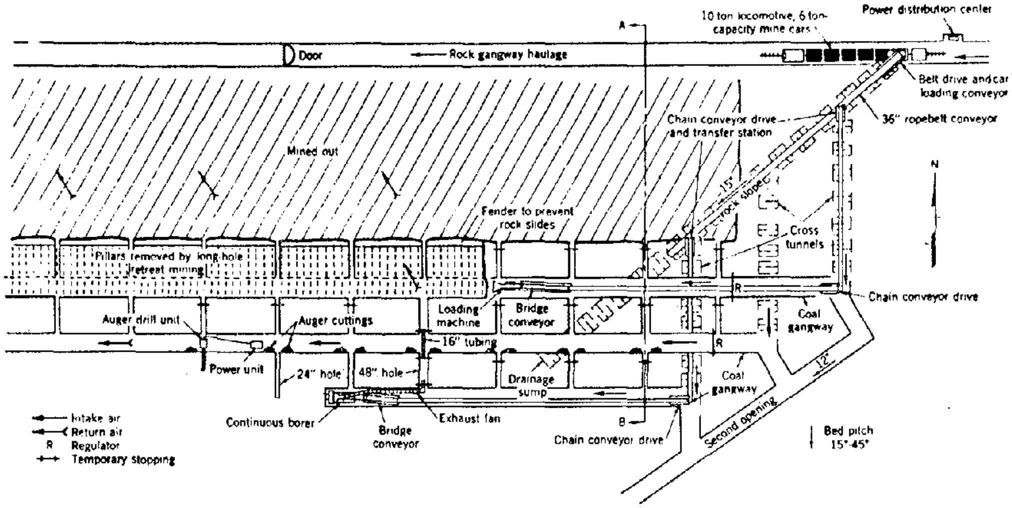
Maximum drilling depth: 87 feet (machine rated for 100 feet).
Pitches: minus 45 to plus 90 degrees.
Total weight, drill and power units: 26,000 lbs.
Recorded penetration rate: one inch per minute in hard shale to nine ipm in shelly coal. Average 3.2 ipm.
Diameter of hole: 24 inches, can be enlarged to 48 inches by back-reaming (which necessitates access to the far end of the hole in order to fit the reamer).

C.2.b Advantages

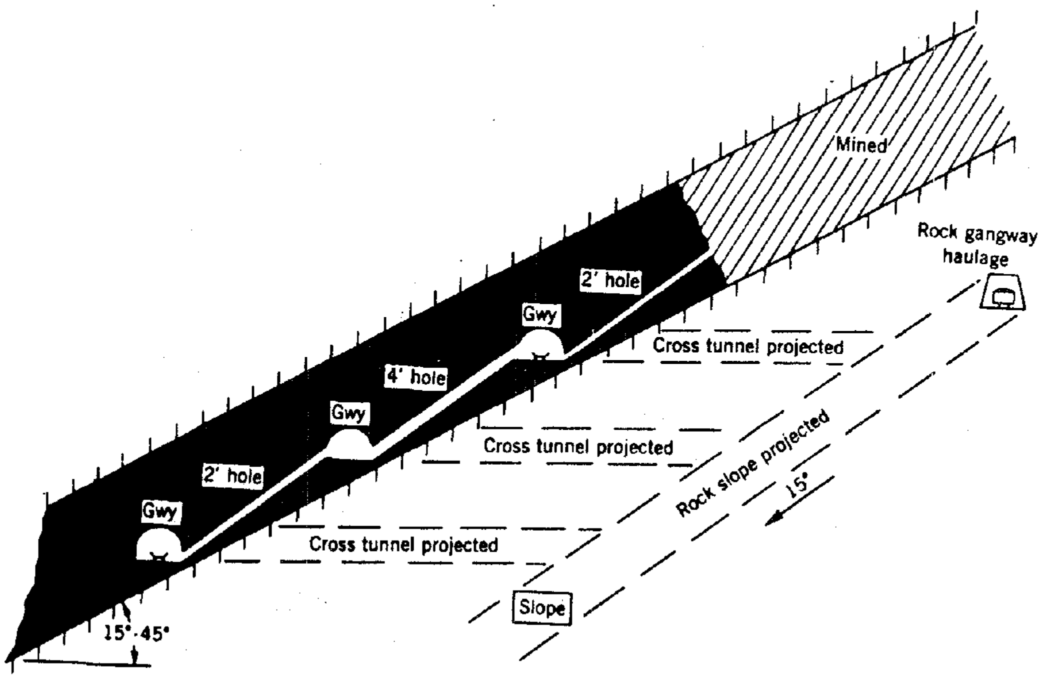
The auger was able to drill 45 foot long ventilation openings at the rate of 18 feet per man-shift (using a two-man crew) compared with 1.6 feet per man shift by conventional mining. The opening was only three square

[1]J. T. Schimmel, W. H. Tavenner and Donald Markle, Jr., Use of a Large Diameter Auger in Mining Pitching Anthracite Beds, U. S. Bureau of Mines, RI 6135, 1962.

USE OF CONTINUOUS BORER AND LARGE DIAMETER AUGER



Development, Method of Mining and Deploying Equipment.



Cross Section A-B ———— Showing Coalbed and Relative Position of Rock Gangway Haulage, Rock Slope, Cross Tunnels, Coal Gangways, and Auger Holes.

SOURCE: Bureau of Mines Report of Investigations 6759

PLATE V - 2

feet, compared with 52 square feet, but served the ventilation purpose adequately.

As the auger was being used in conjunction with a continuous miner, this speed in cutting was essential in order not to hold up the miner. Furthermore, in dip drilling the auger holes could be drilled ahead of the coal gangways, thus giving ventilation as soon as the gangway met the auger hole.

The auger was also used as the opening cut for coal to be blasted, to probe for gas, to determine the nature and extent of unusual pressures, and for water-infusion experiments. The holes reamed to 48 inches were used for conveyor transportation, as escapeways or as second openings between tunnels.

Augering eliminates exposure to the hazards encountered in driving chute-work by conventional methods.

The 24 inch auger hole was strong in self support compared to conventional chute-work.

C.2.c Limitations

A maximum down pitch capability of 45 degrees could be a problem in steeply pitching seams.

Since placing and removing blocking for the drill unit requires considerable time, the addition of rigidly attached jacks at the four corners would reduce the need for blocking in setting up the drill unit and thus increase production.

The heavy scrolls of 140 pounds each would be less arduous and improve safety for the auger man if they could be reduced to less than 100 pounds.

C.2.d Conclusions

The auger satisfactorily performed all the tasks for which it was purchased. It could also be used, in a limited capacity, as a coal-winning machine in thin seams or in removing selected portions of a thick bed.

C.3 Longhole Retreat Mining[1]

C.3.a General Test Conditions

Tests were performed in the Southern Field using the Primrose Vein, which was nine feet thick at the site and pitched 82 degrees. The vein pinched to about one foot thick approximately 35 to 70 feet above the gangway.

The gangway had been developed from earlier experimental mining. Retreat mining using longhole techniques started in June, 1950, and terminated March, 1951.

Initial holes were drilled to 30 foot lengths and loaded with one stick of dynamite per foot of hole. After initial development of the first chute, each succeeding shot required that only one hole be drilled and fired.

Loading was attempted using a duckbill loader and shaker conveyor. A soft bottom rendered the duckbill inefficient and the conveyor was loaded by removing the gangway sets and starting a gravity feed.

Where drilling was not necessary it was eliminated.

C.3.b Advantages

Production rates (85 percent recovery) in longhole mining are favorable with a corresponding reduction in operating costs.

The miner was not exposed to more hazardous conditions and found the resulting work less arduous.

By controlling the charge, sidewalls would remain intact on steep pitches.

A minimum of equipment and maintenance is required.

A pneumatic pick hammer proved effective in breaking up large pieces of material on the conveyor, thus eliminating the necessity to dynamite and its associated risks.

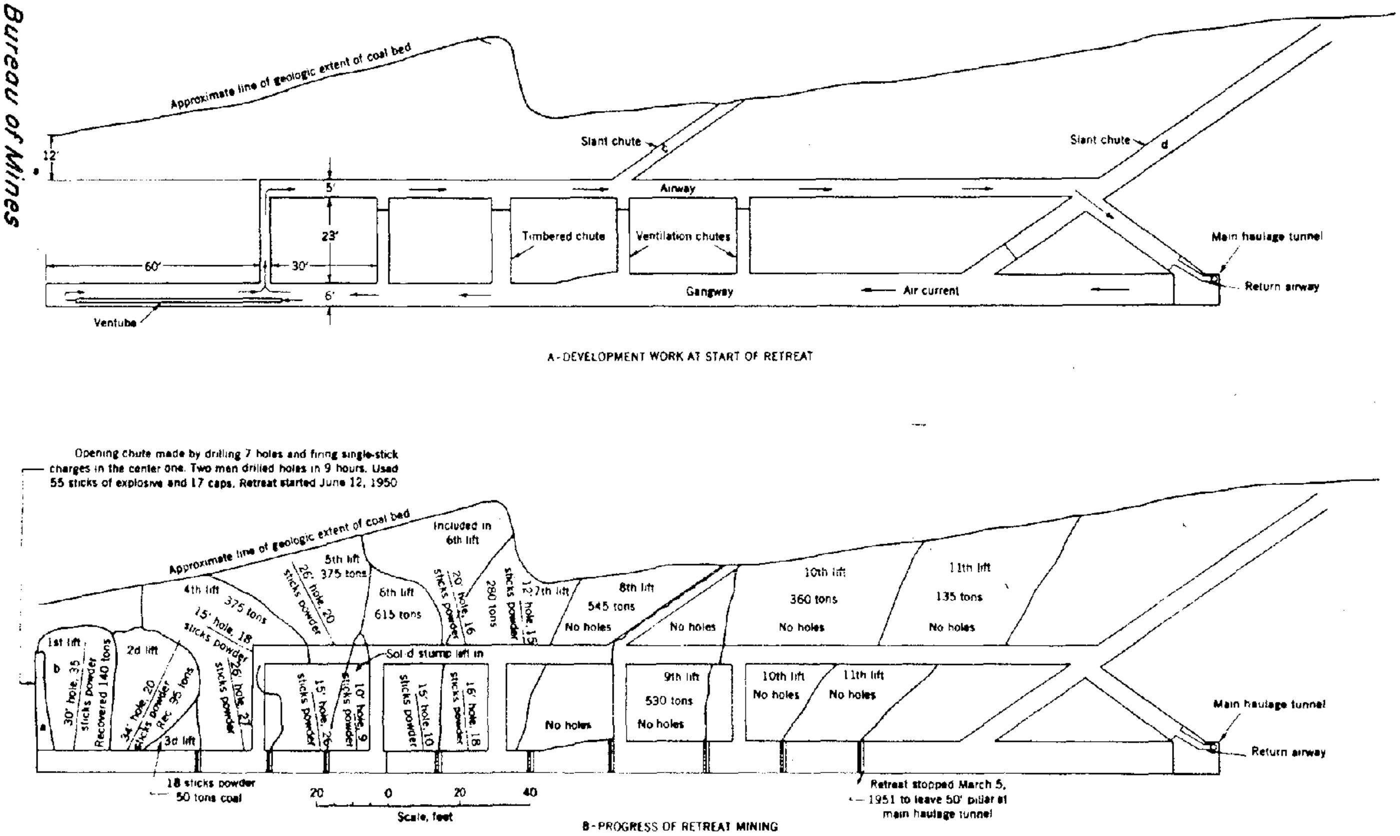
Low consumption of explosives reduces cost and increases safety.

---

[1]Andrew Allan, Jr., and Russell S. Davies, Anthracite Mechanical Mining Investigations, Progress Report 7, "Longhole Retreat Mining of a Steeply Pitching Anthracite Bed", 1952.

LONGHOLE RETREAT MINING

SOURCE: Bureau of Mines Report of Investigations 4925



Progress of longhole retreat mining.

PLATE V - 3

230

C.3.c <u>Limitations</u>

The duckbill loading proved ineffective in soft, wet floor conditions.

Rock falls into the battery did cause loading delays.

Falling timber caused delays by jamming the battery opening and stopping coal flow.

C.3.d <u>Conclusions</u>

The longhole system proved feasible by recovering 11.4 tons per man shift and used only 0.12 pounds of explosive per ton of coal.

The method used provides workers with a safe working area by virtually eliminating the requirement to work under an unsupported roof.

Recovery could approach 100 percent by using rock gangways to convey materials.

Further examination should be pursued on veins pitching 45 degrees to 60 degrees in order to evaluate the roof stresses incurred.

C.4 <u>Yielding Steel Props</u>[1]

C.4.a <u>General Test Conditions</u>

The evaluation was performed within the Northern Field in the Bottom Red Ash vein. Coal thickness was 76 inches and pitched between ten to 20 degrees.

Testing was conducted at the Wanamie No.19 Mine, Glen Alden Coal Company, Wanamie, Luzerne County. The test period began in October 1957 and terminated in December 1959.

The overlying strata was hard sandstone layers, totalling 60 feet thick with total overburden 150 feet. Caving was historically a problem only when exposed over large areas.

Equipment is described as a friction type yielding steel roof support:

Props were Becorit, Type D, heavy duty friction type.
Carrying capacity rating - 50 tons each at yield point of 0.4 inches.

---

[1]Robert J. Brennon, John W. Buch and Edward R. Navrocky, <u>Experimental Longwall Mining in Pennsylvania Anthracite Mine (In Two Parts)</u>, "1. Use of Yielding Steel Props", U. S. Bureau of Mines, RI 6378, 1964.

Weight 180 pounds.
Precautionary cribs were constructed along the break line on six foot centers, and later ten foot centers.
Prop density installed was 1.29 per square meter before shearing, including prop-free face, and 2.58 per square meter in the supported area (maximum possible with adequate working space).
Distance from solid coal to break line was 14 foot 6 inches, later reduced to ten feet.

C.4.b Advantages

None.

C.4.c Limitations

The yielding steel props proved inadequate due to insufficient yield strengths, irregular prop performance and lack of mobility.

The system as a whole failed to control for breaking the overhanging roof at the break line supports. The final result was that the roof broke over the coal and, in effect, destroyed roof continuity in the work area. The project was then discontinued.

Delays concerning prop advancement were extremely tedious and a hindering fact to the longwall mining operations, requiring the time of two out of four shifts in a four foot face advance.

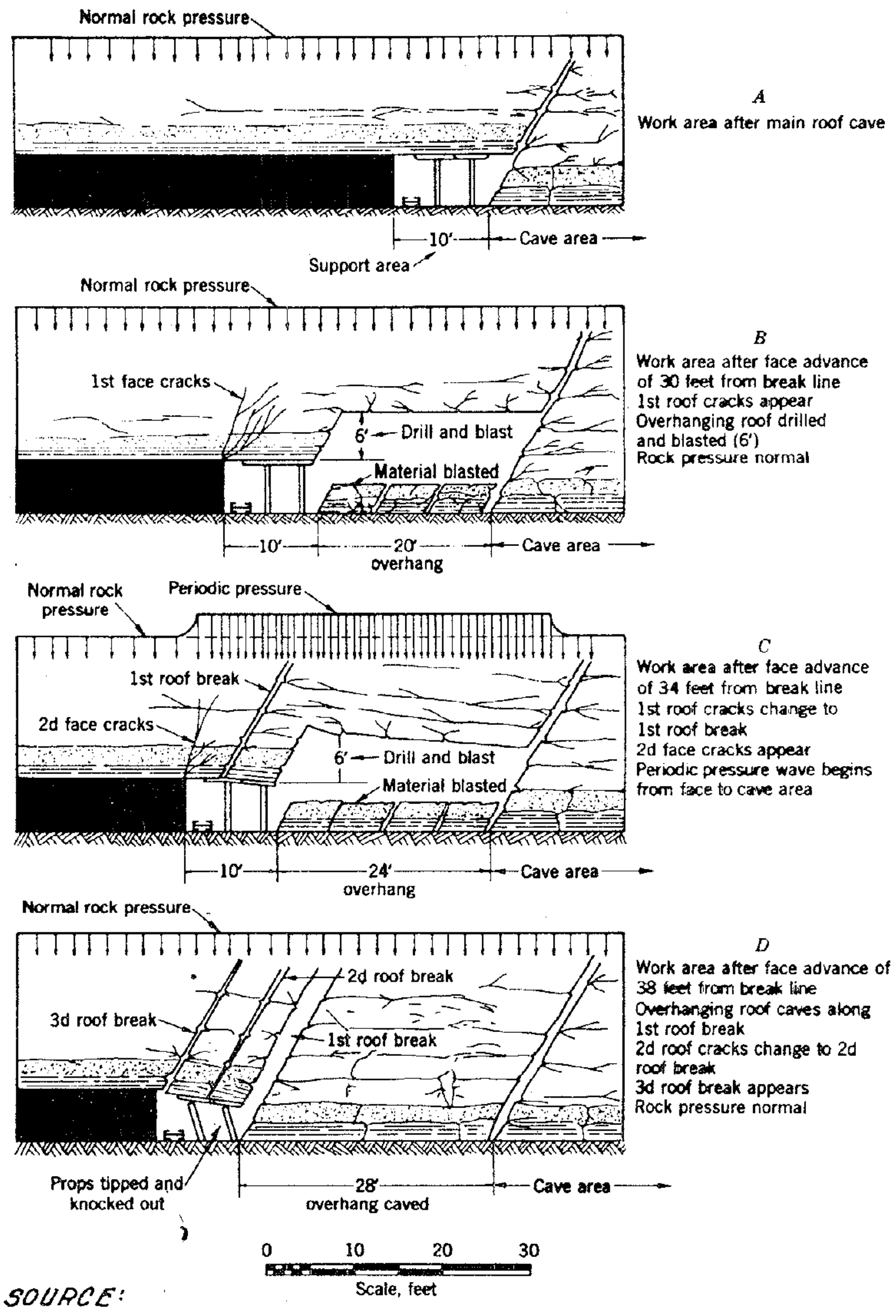
C.4.d Conclusions

The roof load imposed for anthracite on break line supports has, in effect, exceeded 450 tons per prop installed on four foot centers.

The mine test and bench tests showed that coal dust and corrosion further reduce friction in yielding steel props.

Self advancing roof supports that will assure a sustained high-load acceptance over a continuous period of time are essential for mobility and economic success in continuous mining.

PERIODIC-ROOF-WEIGHT CYCLE



SOURCE:
Bureau of Mine
Report of Investigations 6745-1

PLATE V - 4

C.5 Use of a Shearer Loader[1]

C.5.a General Test Conditions

The evaluation was held within the Northern Field in the Bottom Red Ash Vein. The coal thickness averaged 66 inches to 96 inches and was pitched ten degrees to 20 degrees.

Testing was conducted at the Wanamie No.19 Mine, Glen Alden Coal Company, Wanamie, Luzerne County. The test period began during 1957 and was abandoned in 1959 in order not to interfere with the mine's routine operations. The work coincided with the yielding steel prop test previously discussed.

Equipment is described as a European longwall drum cutter loader modified by replacing the bar and chain assembly with a cutting drum and a top cutting jib used in conjunction with an armored chain conveyor.

Drum was 36 inch diameter, rotated 68 rpm.
Top cutting jib provided total 56 inch cutting height.
Powered by 110 hp, 440 V, ac permissible electric motor.
Rope tension required was five tons with a nine ton overload.
Traverse speed was variable - 0 to 16.4 fpm.
Employed Bureau of Mines designed dust suppression system of nine spray nozzles delivering 15 gpm at 500 psi.
Armored chain conveyor rated at 200 tons per hour.
Two foot face advance with each double pass of machine.

C.5.b Advantages

When operating at its best, the longwall shearer loader mined 5000 tons of coal while advancing 65 feet. Shearing along the face averaged 5.2 feet per minute (2.4 tons per minute). This compares to one bituminous installation at Sunnyside, Utah, where the the cutting rate was a maximum of 20 fpm, good cutting 13½ fpm, and hard cutting seven to eight fpm. The main cause of reduced efficiency was in roof support and not the shearer loader.

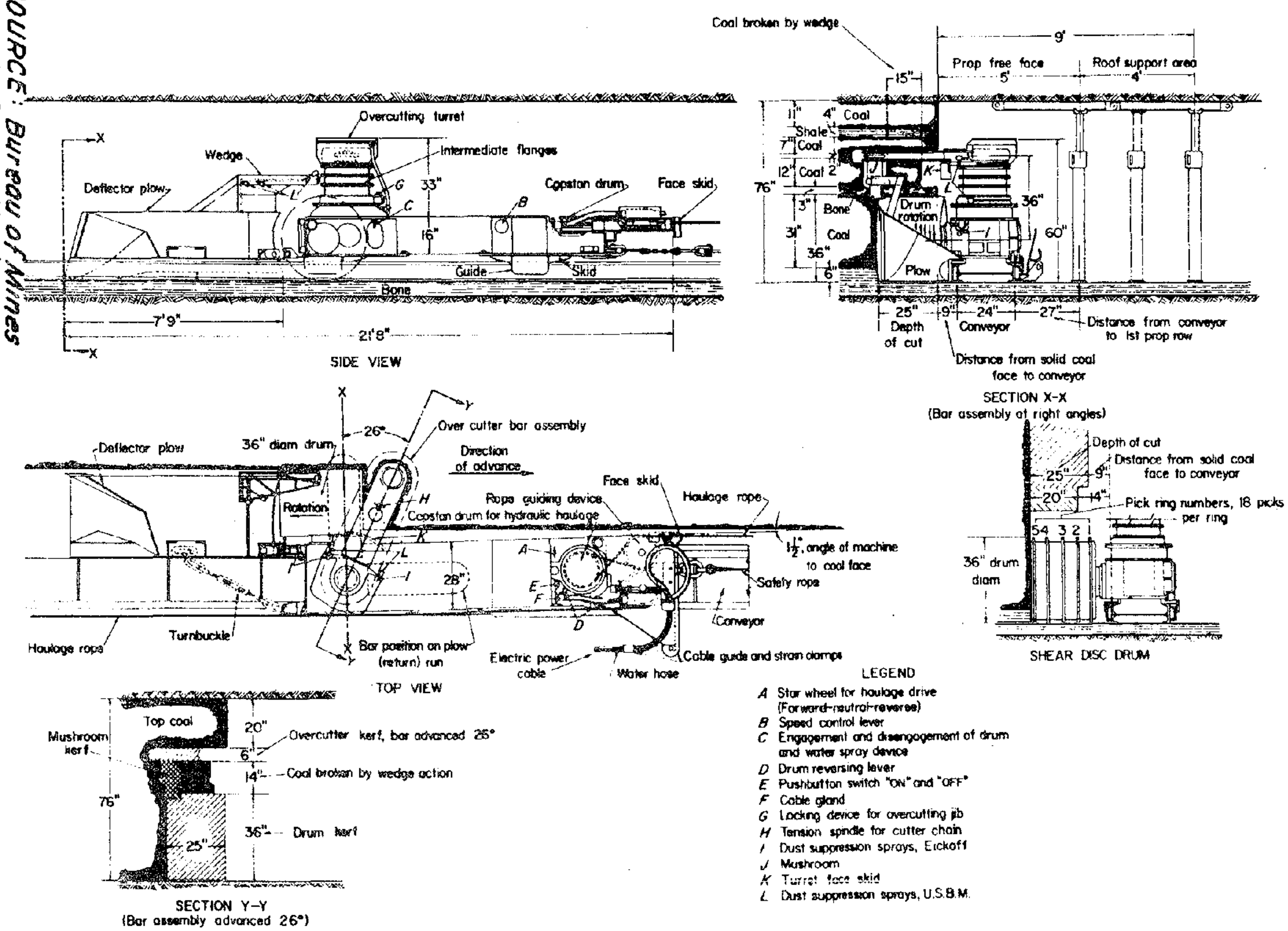
C.5.c Limitations

In this longwall project the drum had no ranging capabilities and thus could not adapt to varying vein thickness, or undulating roof and floor line. When dipping - it left bottom coal to be taken by hand, and, when rising -

---

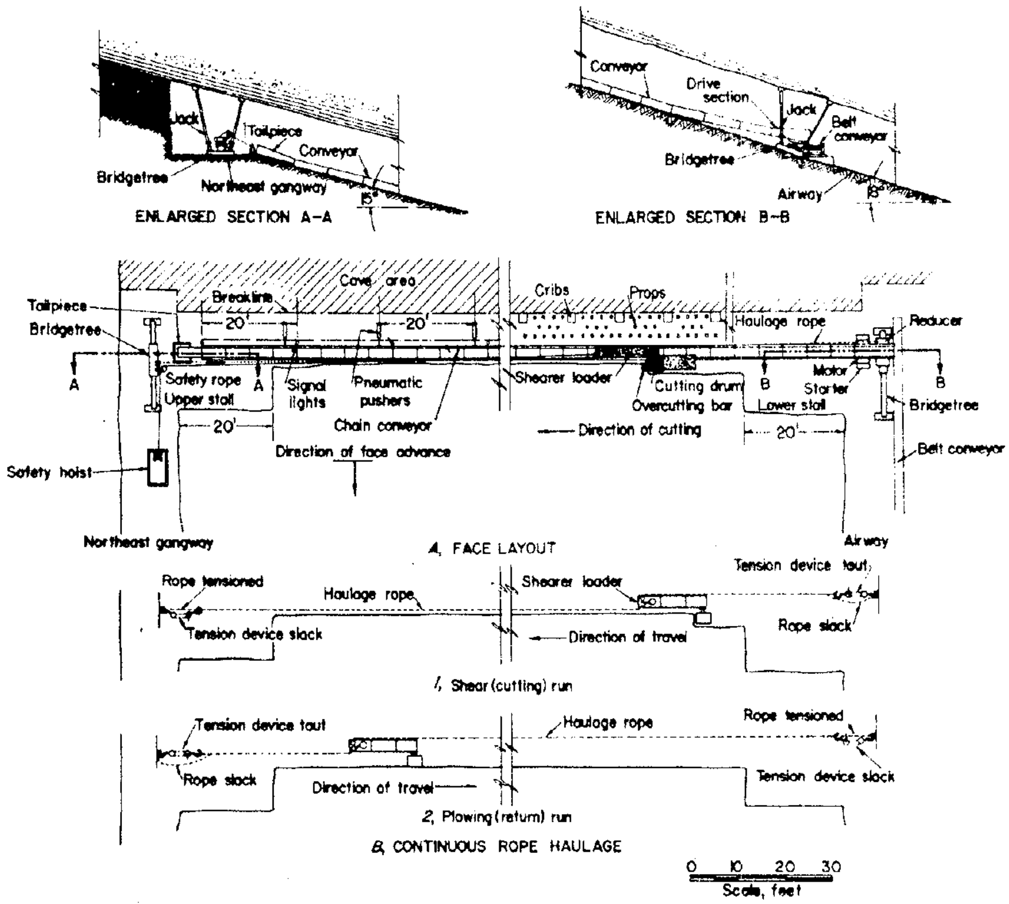
[1]Wilbert T. Malenka and Robert J. Brennan, Experimental Longwall Mining in a Pennsylvania Anthracite Mine (In Two Parts), "2. Use of a Shearer Loader", U. S. Bureau of Mines, RI 6745, 1966.

SOURCE: Bureau of Mines Report of Investigations 6745



Dimensional Views of Drum Cutter Loader and Average Cutting Pattern.

SHEARER LOADER



SOURCE: Bureau of Mines Report of Investigations 6745

PLATE V - 6

the machine would strike rock requiring the jacking and blocking of the machine. All coal above the 56 inch limits required blasting for removal. In short, the machine was inflexible.

The top cutting jib would not penetrate a minimum bed thickness in the upright position and had to be inverted.

Periods of delays during operational time nearly equalled the actual cutting time, due to the shearer riding off the face conveyor, equipment down, power outages, breaking lumps, adjusting sprays, waiting for cars, etc. Average time for a two foot face advance cycle for winning and loading coal was 67 minutes (six percent) for preparation, 186 minutes (17 percent) for shearing and loading 167 minutes (15 percent) for delays, and 62 percent for second shift (drill, load, advance conveyor, top coal, supplies, etc.). Overall production was 7.7 tons per man-shift, which is not attractive, due mainly to time-consuming roof support work.

Yielding steel prop roof support systems were a continuous delay problem. In each four foot advance required for roof support cycle (340 tons), an average of four seven hour shifts was required, consisting of two shifts for winning and loading coal (as above) and two for roof support.

C.5.d Conclusions

A ranging cutter head is necessary to fully mine an irregular vein thickness.

Integral hydraulic lifting jacks were found to be necessary at each corner of the machine.

Hydraulic props or self advancing roof supports should be used that are rated in excess of 400 tons and spaced at two-and-a-half to four foot centers.

The dust suppression system could be improved with more nozzles delivering more water at higher pressures.

C.6 Longwall Mining on 30 Degree Seams[1]

C.6.a General Test Conditions

In 1966, this test operation was developed for mining the five foot thick, 30 degree pitch bituminous B seam of the Mesa Verde Formation, Thompson Creek District No.1 Mine, Pitkin, Colorado.

---

[1]Albert M. Keenan, Longwall Mining of Coal Seams Pitching 30 Degrees, AIME Paper No.71-F-336, Presented to the Society of Mining Engineers of AIME, September, 1971.

The equipment used in mining consisted of:

A German Klockner-Ferromatic self-advancing powered roof support system (double chock), 70 ton rating.
An electric powered, hydraulic operated shearer loader with a 48 inch diameter cutting drum and 30 inch face.
A double chain armored conveyor was installed along the longwall.

The longwall established was a 320 foot face, advancing an average of three feet per cut by means of an hydraulic movement which effectively held the cutting drum to the face.

C.6.b Advantages

Successful longwall advance was performed on a seam inclined at 30 degrees by equipment which was not specifically designed to operate at such an angle.

Retreat longwall mining proved to be a more ideal method.

A minimum number of development entries is both required and preferred. One entry on each end of the longwall has been found to be most effective. Open areas at cross cuts contribute to unsafe conditions.

C.6.c Limitations

Strike and slope entries were driven manually and would have to be mechanized to keep up with the shearer loader. It is most important that strike entries be driven substantially ahead of longwall face extraction.

Faults and similar geological features proved detrimental to efficient longwall operations and required that a spare longwall face be held in readiness to insure continuity of production.

Roof stresses which developed at or behind the face were critical and required constant inspection.

Realignment of the roof supports to provide uniform support after advance was time consuming.

Dust control is a problem in the vicinity of the cutting drum.

C.6.d Conclusions

Detailed operating statistics were not available, but the production in the mine increased substantially in the period of experimentation over the prior room and pillar system.

Longwall mining can be done on 30 degree pitches, and consideration should be given to seams of lesser or greater pitch.

Entries were not driven mechanically, but it was concluded that a cutting drum which will cut both coal and bottom rock without changing heads or power is needed for mechanical driving of entries to give sufficient height. The same machine could not be used in cross cuts since these would only be in coal and effective machine transfer could not be made. The future use of an auger is being considered for cross cuts. The use of an "Alpine Miner" of Austrian manufacture is being considered for mine development of entries.

Hydraulic jets (hydraulic mining) may be a better means of coal cutting than either a shearer loader or a planer in the interest of dust suppression, especially if combined with hydraulic transport.

The more recently developed Klockner-Ferromatic Ferromat 2/4 with a two frame, four leg supporting unit may be more applicable to pitching seams. It should aid in essential uniform roof control across the face since the frames always follow fixed points on the conveyor. Time-wasting realignment work is thus eliminated.

C.7 Continuous Mining System[1]

C.7.a General Test Conditions

This test was a joint effort by the Coal Research Board (Pennsylvania), The Pennsylvania State University, and the Blue Coal Corporation.

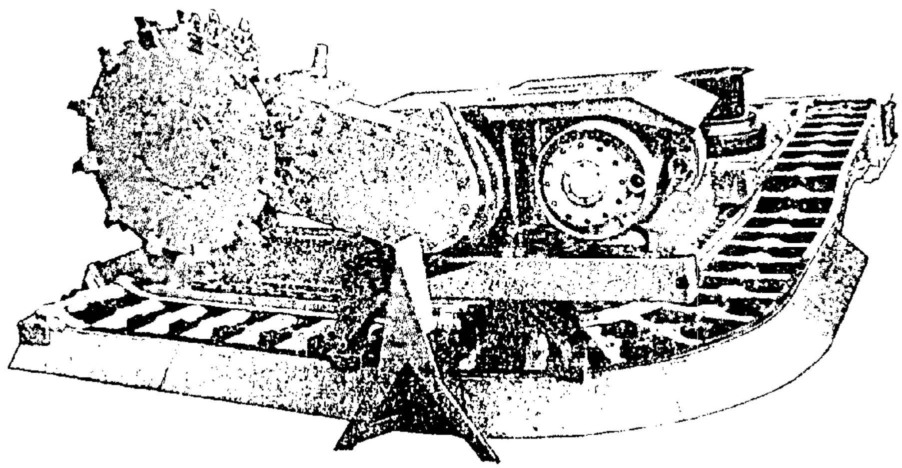
The evaluation of the mining system was performed in the Northern Field. Blue Coal Corporation installed the equipment in its Wanamie No.19 Colliery and worked the Bottom Red Ash Vein. The coal averaged seven and one-half feet thick and pitched 20 to 25 degrees. The depth of cover varied from 350 to 500 feet. Testing commenced about 1968.

The mining system evaluated was the Muniko Miner, a drum-type shearing machine mounted over armored chain conveyors capable of negotiating 90 degree bends. The drum is mounted horizontally on a shaft driven by a 125 HP, 440 volt motor and is hydraulically adjustable on a swivel axis for varying heights. The cutting drum was 14 inches wide, and could cut a section four foot six inches high.

---

[1]G. Mishra and R. Stefanko, Application of a Continuous Mining System in a Medium Pitching Anthracite Bed of Northeastern Pennsylvania, Pennsylvania State University, SR-77, 1970.

RANGING DRUM SHEARER



MUNIKO MINER WITH THE CURVED PANZER CONVEYOR

SOURCE: Pa. Coal Research Board
Special Research Report No. SR-77

PLATE V - 7

The Muniko cut a gangway 15 feet wide and advanced 325 feet until a roll intruded into the seam and pinched the roof to three feet.

Immediate face support was with two ten-ton Hyjack props.

Ventilation through the intake slope was 43,000 cfm and was sufficient, except at the face.

It was also planned to test a Miniranger in 1970, but results are not listed in the report.

C.7.b Advantages

The ranging arm allows the shearing machine to follow the coal vein undulations and is capable of reaching below the conveyor level to the floor.

The drum is adaptable to pillar extraction by using modified short wall methods.

The vein thickness mined may vary from three and one-half feet to ten feet.

The equipment uses an integrated hydraulic advancing system which is advantageous for changing floor and roof conditions.

The machine can negotiate faults up to 40 inches of throw.

C.7.c Limitations

A pinch in the vein to three feet required hand mining and the shifting of the machine to a new location.

Acid water proved detrimental to machine parts.

The drum frequently cut into rock because of roof and floor undulations. Bit wear and tear was most significant during the first weeks.

Pyrites in the bed were extremely hard and caused excessive cutter pin breakage. Coal had to be blasted when pyrites were present.

Dust suppression sprays were not effective in spite of 40 HP, 40 gpm spray pumps working at 150 psi.

On pitches beyond ten degrees the conveyor had to be held in place with sprags to prevent it from sliding down the dip.

Heavy inflow from rainfall was difficult to control.

There were two major breakdowns in the hydraulic system.

Haulage problems were a limiting production factor.

Setting roof supports was the most time consuming delay incurred.

C.7.d Conclusions

Limited time and circumstances beyond control did not allow full evaluation of the system and, thus, the tests can only be considered as a preliminary evaluation.

Due to unfavorable geologic conditions and the discontinuance of operations, the machine ran smoothly for only four weeks out of ten months.

In this period coal was mined continuously at an average of 30.5 tons per shift (three times the hand mining rate for the mine).

Roof support improvements are necessary for expanded use of the continuous shearing machine. Self-advancing hydraulic chocks may improve delay time.

Improvements in the cutting power and bit hardness are necessary to compensate for pyrites and rapidly varying seam thickness.

A closed loop transportation system is essential to maintain a high rate of advance.

C.8 Pneumatic Coal Planer[1]

C.8.a General Test Conditions

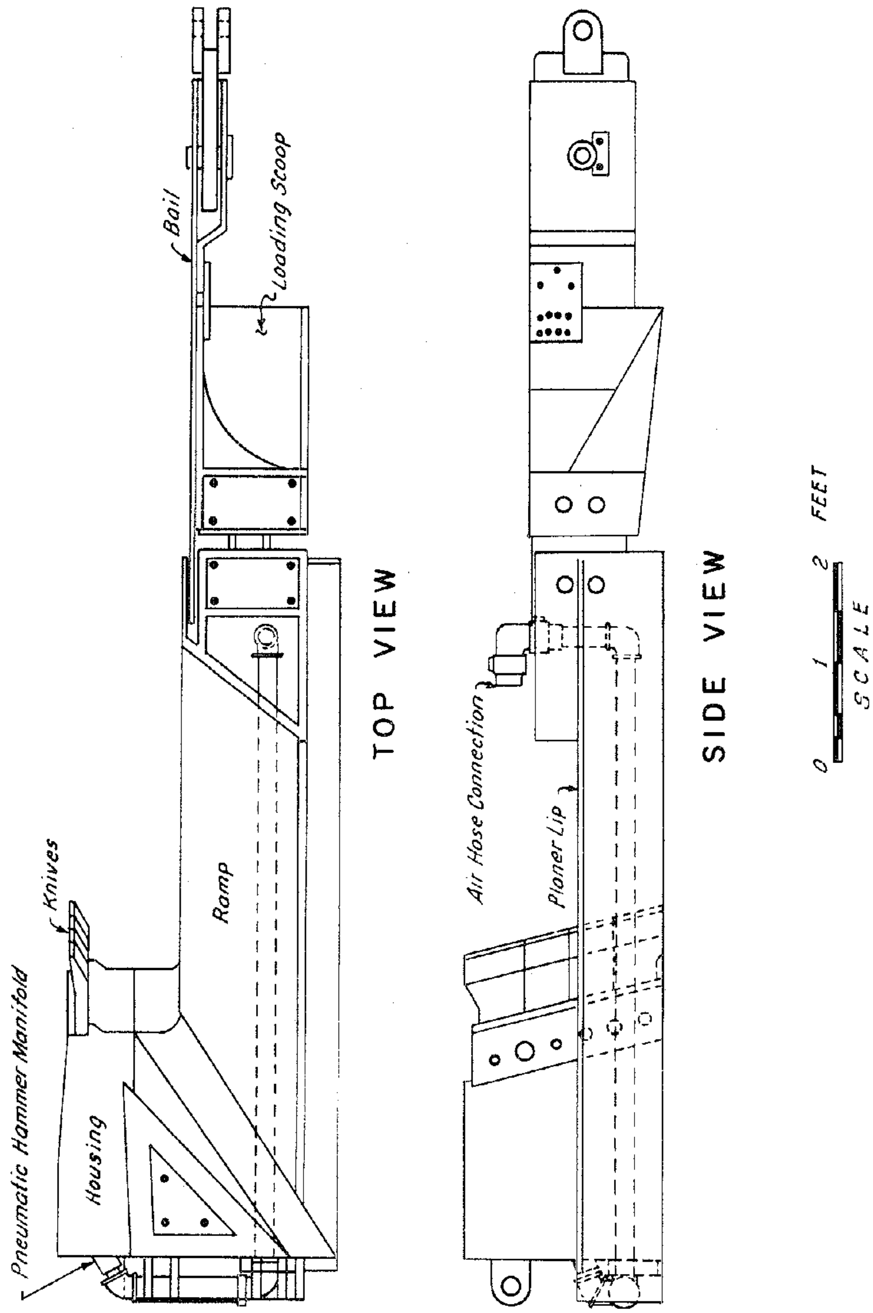
The pneumatic planer was evaluated at Plains, Pennsylvania, in the Lehigh Valley Coal Company's workings. The vein used was the Upper Five-foot Bed which averaged five feet thickness and pitched zero to 25 degrees in the test area. The depth of the overburden was 217 feet, and the immediate cover was 20 inches of strong bony material.

The planer is composed of a pneumatic hammer and knife assembly which is guided over the face by means of a pulling chain and winch. The extracted coal is removed by means of a loading scoop which feeds the conveyor.

---

[1]John W. Buch, Walter R. Griffith, and John T. Schimmel, Design and Testing of Bureau of Mines Pneumatic Coal Planer, U. S. Bureau of Mines, RI 5380, 1957.

PNEUMATIC COAL PLANER



SOURCE: Bureau of Mines Report of Investigations 5380

PLATE V - 8

The four six-inch knives form a 24 inch blade which is the cutting surface. A single compressed air line served both the hammers and pushers at a total 100 psi initially and at 50 psi in later tests. (Effective air pressure required was 70 psi). The winch developed a maximum 45 ton pull and the planer travel was 18 feet per minute.

No attempt was made to determine a recovery rate.

No attempt was made to relate the depth of cuts to compressed air requirements.

C.8.b Advantages

Design technology for an operational planer is feasible.

The pneumatic planer with rigid cutting blades will cut anthracite coal.

C.8.c Limitations

The planer evaluated was an experimental design model and not one which is operational.

Cutting could be made in only one direction along the face.

Pneumatic systems would not hold acceptable pressure levels as testing progressed.

Cutting blades of varying hardness all showed some properties which were unfavorable.

Bottom coal, one foot high, was left after each pass, and hand removal was required.

Because the single compressed-air line supplied both the planer and the pushers, there was no direct control over the air line pressure sent to the pusher.

C.8.d Conclusions

A complete redesign of the system is necessary to effectively mine coal.

An effective roof support system designed to supplement a pneumatic planer is required.

There is a need for a continuous miner which will operate safely and efficiently on hard floors and on pitches varying from 10 to 20 degrees.

C.9 Induced Caving[1]

C.9.a General Test Conditions

The test site was in the Southern Field at a former Philadelphia and Reading Coal and Iron Company Colliery, where the Bottom Split Mammoth vein was selected. The vein was 14 feet thick, pitched 70 degrees, and at the test location extended 328 feet to the surface. Only the first 100 feet was solid coal, the balance having been mined by the "room and pillar" method. Fifty percent of the coal remained in the pillars. The tests were evaluated from August 1951 to June 1952.

Four rock chutes were driven into the test coal from a rock gangway located 15 feet under the bed. The bed was then undercut to provide an unsupported area which would accommodate the coal measures after caving was induced.

After undercutting, the coal was then drilled and fired to induce caving towards the rock chutes.

C.9.b Advantages

Production for the induced caving averaged 33.5 tons per man per shift.

There were no lost-time accidents during the study period.

Recovery percentages of coal were high, particularly during the early recovery shifts.

The top did remain intact because of the steep vein pitch.

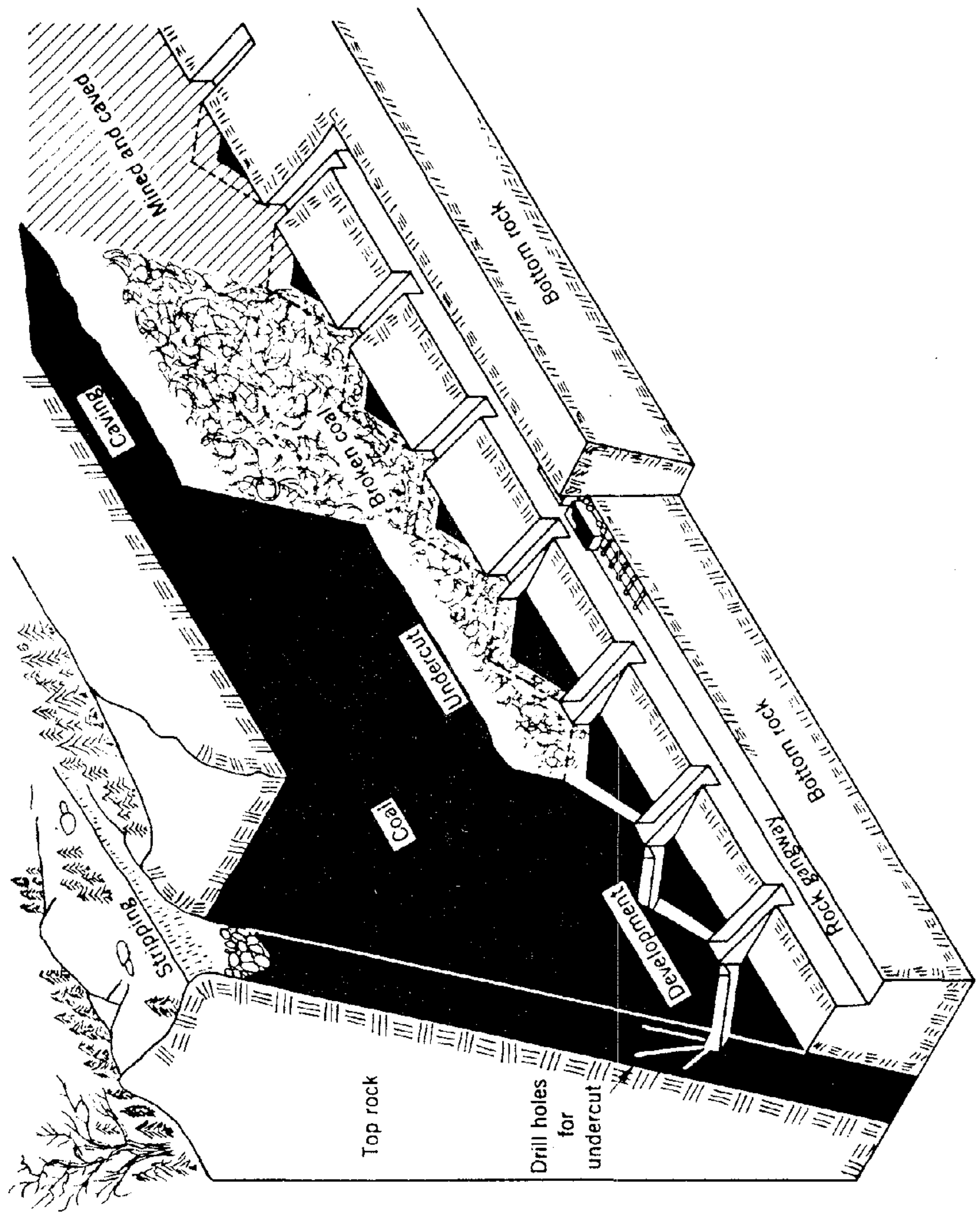
Induced caving eliminates the requirement for long slant-chutes in steep veins.

This method reduces the quantities of dynamite required, the need for extensive timbering plans, and it concentrates supervisory work almost exclusively on the gangway and its immediate area.

---

[1]Andrew Allan, Jr., and R. S. Davies, Anthracite Mechanical Mining Investigations, Progress Report No.5, "Recovery of Anthracite in a Steeply Pitching Bed by Induced Caving", U. S. Bureau of Mines, RI 5013, 1953.

ANTHRACITE RECOVERY BY INDUCED CAVING



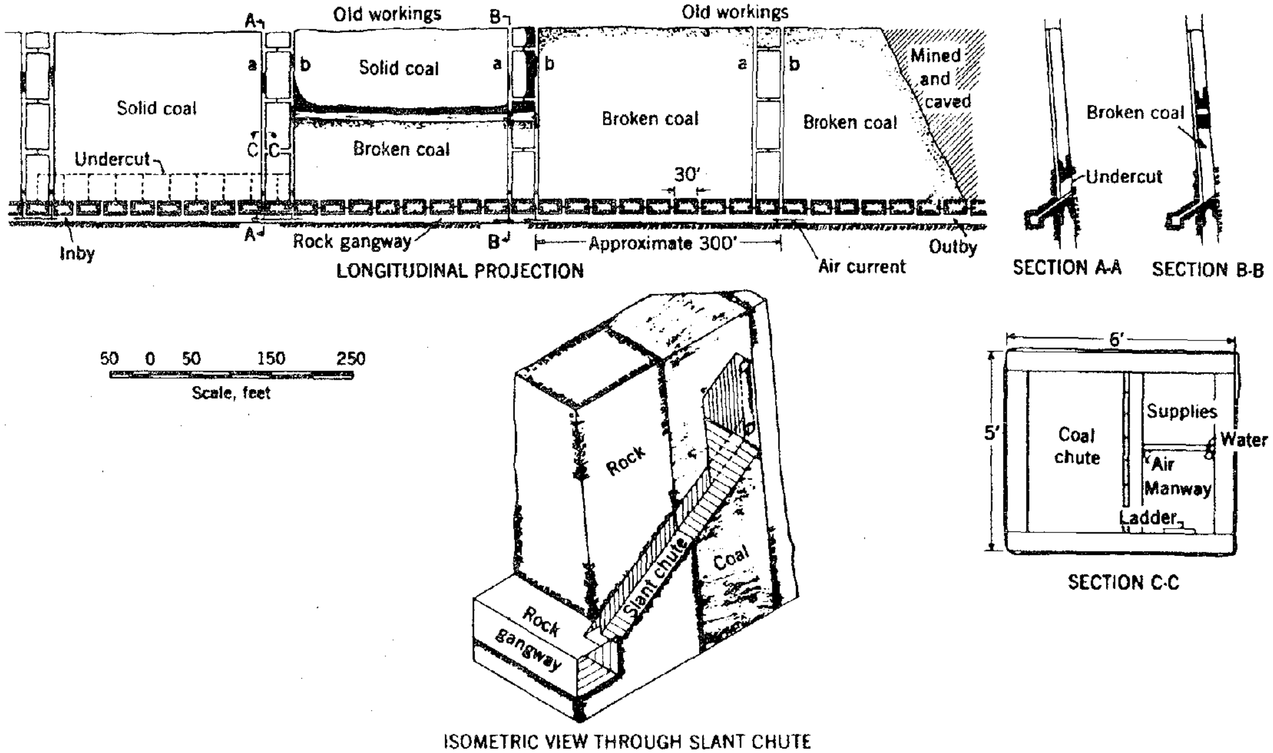
Original conception of induced caving applied to steeply pitching anthracite beds.

SOURCE: Bureau of Mines Report of Investigations 5013

PLATE V - 9

ANTHRACITE RECOVERY BY INDUCED BLOCK CAVING

SOURCE: Bureau of Mines Report of Investigations 5013



Plan for mining steeply pitching anthracite beds by induced block caving.

PLATE V - 10

C.9.c Limitations

Ventilation during caving is still a problem.

Dilution of the coal by rock from gob areas above the caving probably did cut off quantities of coal at the chute during final recovery stages.

Subsidence at the surface can be a definite hazard both to safety and to the environment.

C.9.d Conclusion

Recovery by induced caving in steeply pitched veins is a valid recovery method that well exceeds conventional means.

Induced caving has resulted in an excellent safety record, principally due to the reduced need for dynamite, reduced timbering and hauling supplies, and by concentrating work areas.

Reclamation of surface subsidence will probably be enforced by today's laws.

Dilution of coal can probably be prevented by better engineering workings above future induced cavings.

The use of induced cavings and roof supports on flatter veins (45 degrees to 60 degrees) should be evaluated.

C.10 Lightweight Shearing Machines[1]

C.10.a General Test Conditions

Tests using selected German mining machines were held in the Southern Field for the purpose of developing thin, steeply pitched beds. The test period was from February to August, 1949, and the seam used was the Primrose Vein, nine feet thick, and which pitched 82 degrees.

Seventy-eight feet of gangway and 108 feet of heading were driven during the evaluation.

The equipment used to evaluate the methodology was:

[1]John W. Buch, Andrew Allan, Jr., and Russell S. Davies, Anthracite Mechanical Mining Investigations, Progress Report No.4, "Status of Bureau of Mines Underground Experimental Work with Lightweight Shearing Machines in Pitching Anthracite Beds", U. S. Bureau of Mines, RI 4798, 1951.

1. Korfmann Universal shearing machine, Model SK-20[1] with modified caterpillar track mount, is a compressed air-operated, rail mounted, cutting-shearing machine. It weighs 3,000 pounds and is equipped with a cutter bar and endless lift-chain. The air-driven turbine motor is rated at 20 HP with 60 psi. Roof and face jacks hold the machine steady during cutting operations.

2. Eickhoff shearing machine, Model DEK[2] is a compressed air operated shearing type using a conventional bar and endless chain cutter design. The shearing assembly is mounted on a crawler chassis so that the cutter bar and motor can be rotated 360 degrees about a vertical axis. The model stands three feet high, weighs 1600 pounds, and cuts a kerf six feet deep, three inches wide. The cutter motor develops nine BHP at 60 psi and the chain rotates at 425 rpm.

3. Scraper-Shaker Loading Machine.[3] The machine consisted of a Bureau designed hoe-type scraper slide attached to a shaker-conveyor and drive trough. The scraper gathers coal and/or rock from the gangway face and delivers it to the shaker conveyor drive trough. The drive trough then extends overhead along the gangway a sufficient distance in order to load a trip of mine cars. A full face round required ten cars. Therefore the drive trough had to extend a ten car trip (120 feet).

4. Goodman automatic duckbill loader.

5. Compressed air jack hammers and drills.

C.10.b <u>Advantages</u>

Full mechanization proved to be two and one-half times as fast as conventional methods when compared on a lineal foot advance per shift basis.

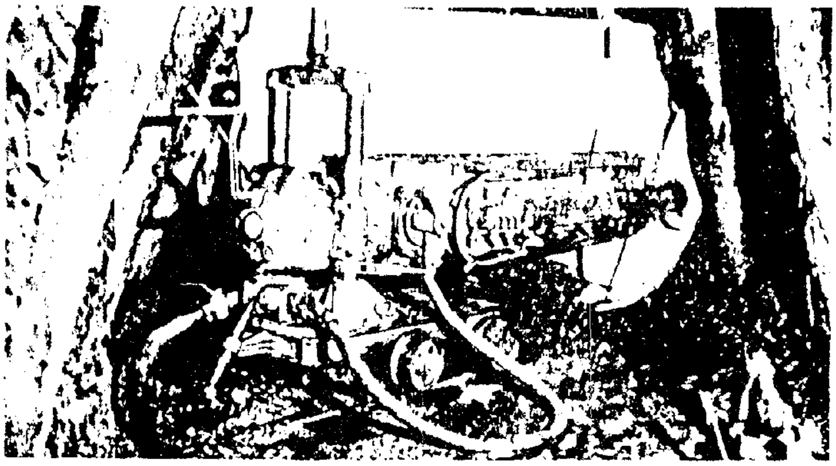
---

[1]John W. Buch and Andrew Allan, Jr., <u>Anthracite Mechanical Mining Investigations</u>, <u>Progress Report No.3</u>, "Preliminary Testing of Korfmann Universal Shearing Machine, Model SK20", U. S. Bureau of Mines, RI 4794, 1951.

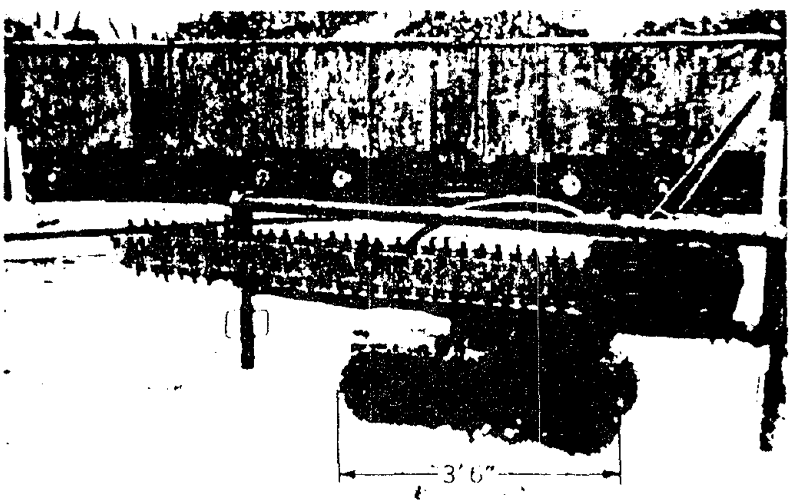
[2]John W. Buch and Andrew Allan, Jr., <u>Anthracite Mechanical Mining Investigations</u>, Progress Report No.2, "Preliminary Testing of Eickhoff Shearing Machine, Model DEK", U. S. Bureau of Mines, RI 4501, 1949.

[3]John W. Buch and Andrew Allan, Jr., <u>Anthracite Mechanical Mining Investigations</u>, <u>Progress Report No.1</u>, "Preliminary Underground Tests of the Bureau of Mines Scraper-Shaker Loading Machine for Driving Gangways", U. S. Bureau of Mines, RI 4500, 1949.

LIGHTWEIGHT SHEARING MACHINES



KORFMANN UNIVERSAL SHEARING MACHINE
MODEL SK 20

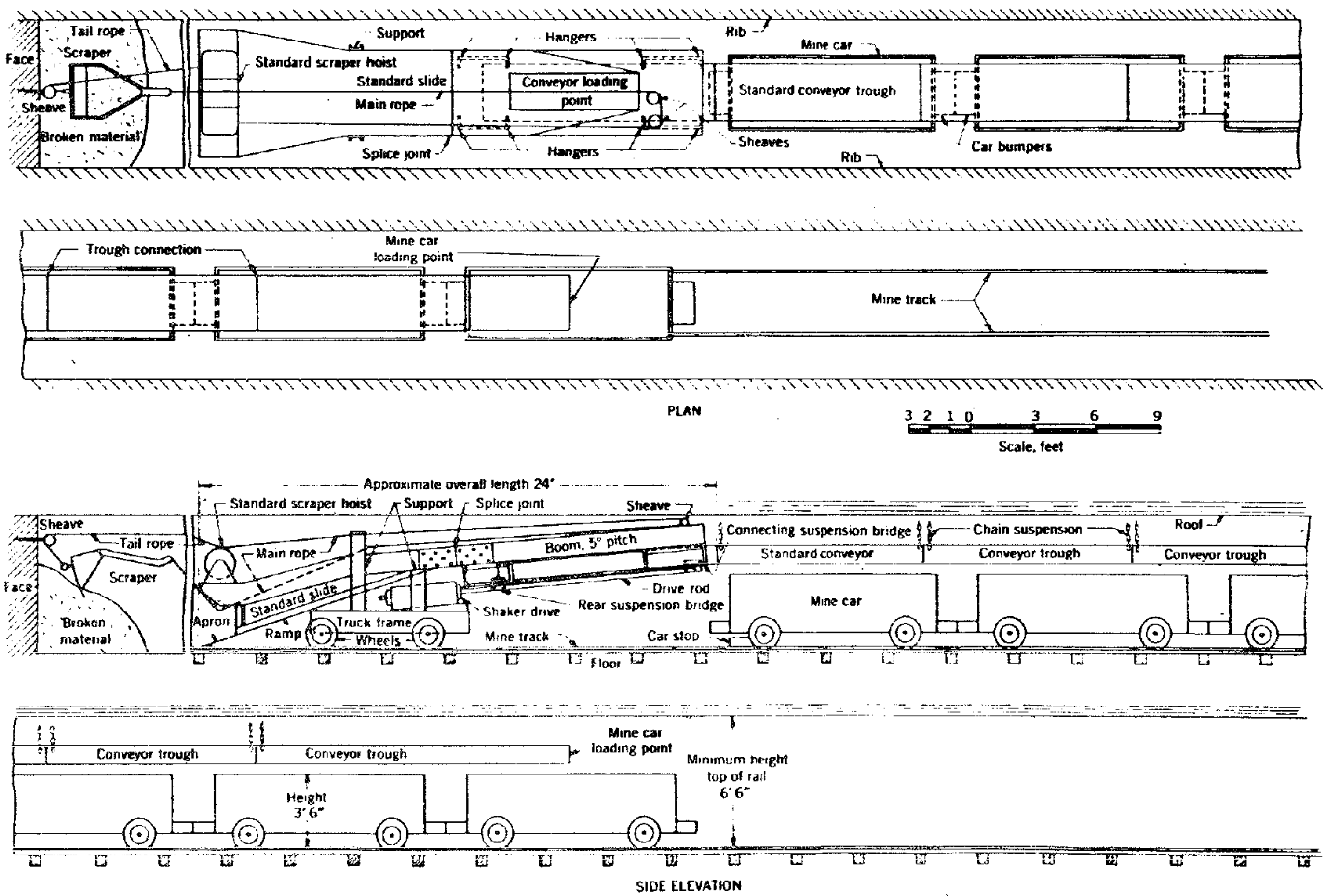


EICKHOFF SHEARING MACHINE
MODEL DEK

SOURCE: Bureau of Mines Report of Investigations 4798

PLATE V - 11

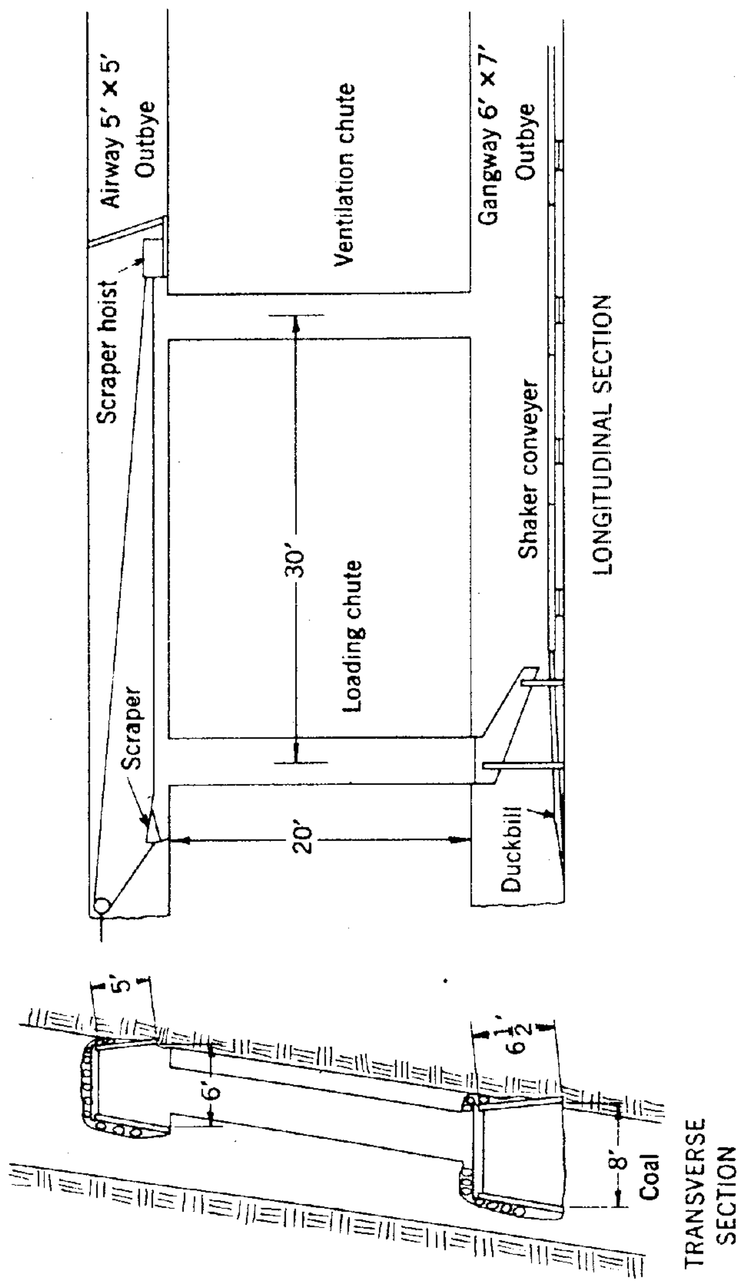
SCRAPER-SHAKER LOADING MACHINE



SOURCE: Bureau of Mines Report of Investigations 4798

PLATE V - 12

SCRAPER WITH DUCKBILL - SHAKER CONVEYOR



SOURCE: Bureau of Mines Report of Investigations 4798

PLATE V - 13

Costs for extracting the coal mechanically were somewhat more than one-third those for conventional means.

The coal was machine loaded by conveyor, thus eliminating the necessity for mine cars and railings. No rock was taken during the experiment.

Timber dislodgement by heavy blasting charges was eliminated. Blasting charges were reduced in size 25 to 50 percent.

Because of the reduced blasting, the fracture condition of coal at the working face was found to be safer.

No electricity was required at the face.

C.10.c Limitations

More than 50 percent of cycle time was spent in face timbering work. The most arduous task in the entire operation was carrying the timbers up 80 degree pitches to the face.

Dust control was maintained by a 500 gallon water tank, under pressure, which fed into single one inch nozzles on each machine. Dust reading was by rule of thumb based on the light pattern from the miner's lamp.

The slide-rod bearings on the shaker conveyors overheated and caused loading time delays.

Feeding coal from the chute to the shaker-conveyor was still an unsolved problem, as was a related problem of conveyor spillage in the gangway.

C.10.d Conclusions

Mechanical mining can be more efficient than conventional hand methods.

Research is required to solve timber handling on steep pitches and on solving roof support problems in general.

Further study is needed to determine the use of auger or large diameter drills to place ventilation chutes.

Dust control is still a problem.

Blasting charges can be reduced greatly with more efficient mining machines.

Solutions to loading and conveying problems are still major goals for future research, as determined by this test.

C.11 Second Testing of Brieden Pneumatic Packing Machine[1]

C.11.a General Test Conditions

The packing machine used was a Brieden Pneumatic, Model KZR-700, imported from Germany. It was the same machine used in an earlier Bureau of Mines test.[2]

Ten feet ten inches long
Three feet seven inches wide
Four feet five inches high
10,580 pounds
20 HP motor rated at 60 psi

The test was conducted in the Top Red Ash Bed, Glen Alden Coal Company, Plymouth, Pennsylvania, starting in November 1953 and continuing through September 1954.

The coal bed ranged in pitch from flat to 15 degrees with an average thickness of 6.75 feet.

Refuse material (three inches and smaller) transported from the preparation plant was used in the packing process. It was blown from the packing site by compressed air through a six inch diameter pipe an average distance of 880 feet.

After the plan to recover the pillars in the packing area was abandoned, the testing of the packing machine stopped.

C.11.b Advantages

Except for lubrication, there was no machine maintenance expense.

It controls strata movement and insures maximum recovery of coal.

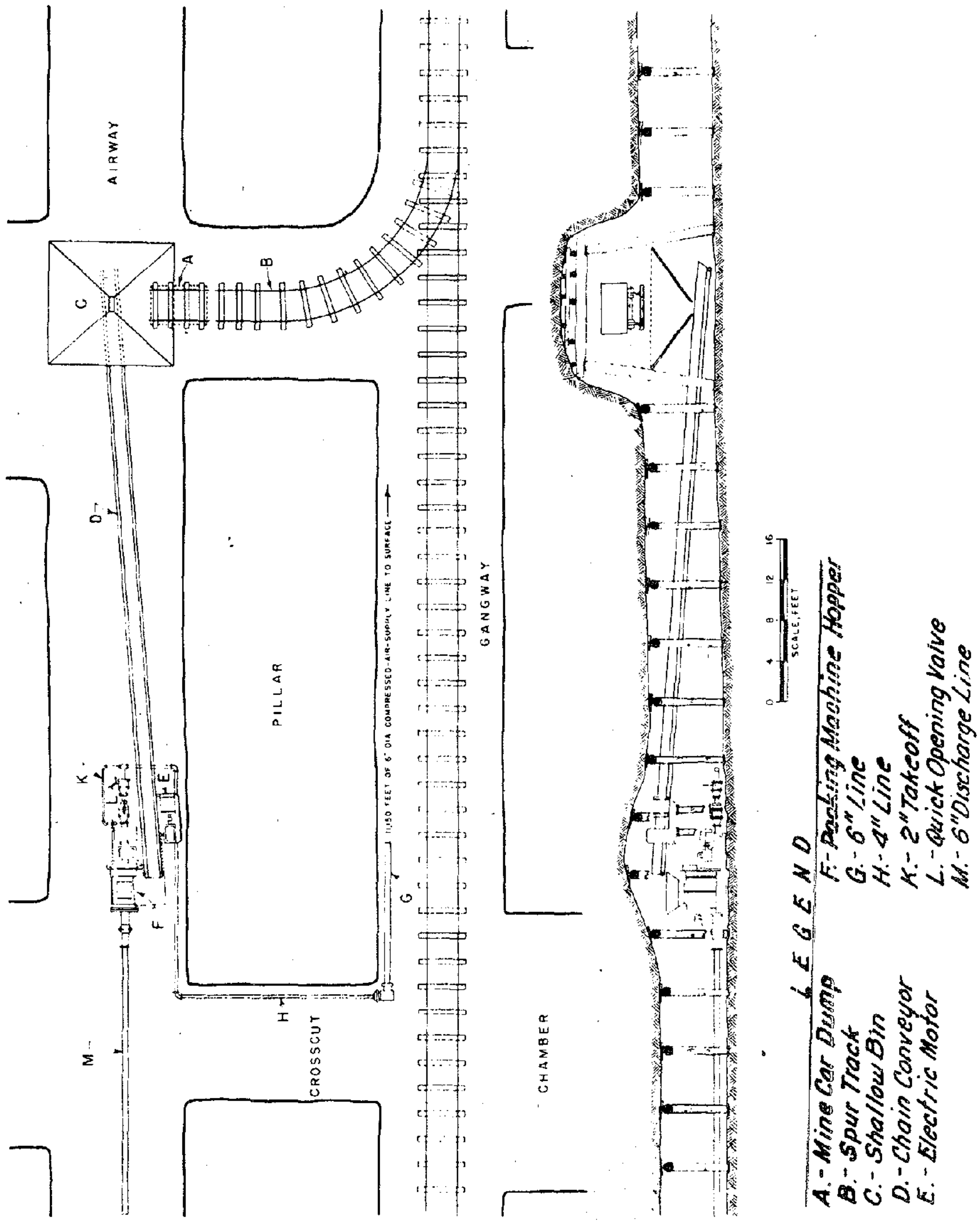
Anthracite refuse appears to be an ideal material for pneumatic packing.

---

[1]Ralph H. Whaite, Anthracite Mechanical Mining Investigations, "Second Testing of Brieden Pneumatic Packing Machine", U. S. Bureau of Mines, RI 5273, 1956.

[2]Clayton A. Landsidle, John C. Hartley, and John W. Buch, Anthracite Mechanical Mining Investigations, Progress Report No.6, "Preliminary Testing of Brieden Pneumatic Packing Machine", U. S. Bureau of Mines, RI 4978, 1953.

PNEUMATIC PACKING MACHINE



SOURCE: Bureau of Mines
Report of Investigations 5273

PLATE V - 14

Pneumatic packing is more economical than any other type of backfilling.

C.11.c Limitations

Because plans were dropped to recover the pillars, there was no observation of the effectiveness of pneumatic packing for strata control during pillar recovery.

The major maintenance cost was for the six inch round discharge pipe, mainly at the elbows and bends. Higher-grade steel would reduce this.

Performance of the machine was reduced because only 65 percent of the design air pressure was available.

Pneumatic backfilling has a problem of fitting in with the daily mining operations.

No economies in the cost of production accrue to the operator from pneumatic packing.

An insufficient supply of packing material caused several shifts to reduce their packing rate.

C.11.d Conclusions

Pneumatic packing offers an artificial strata support, while maximizing the amount of anthracite recovered after first mining.

A 45 percent shift performance increase was observed when compared with the pneumatic packer in the first test in 1950.

Except for the pneumatic packer, Germany and Great Britain have abandoned all other methods of backfilling.

The average packing rate was 36.7 tons per hour with a maximum of 49.5 tons per hour noted.

The effectiveness of pneumatically packed material in controlling subsidence needs to be evaluated.

C.12 Suspended Monorail System[1] [2]

C.12.a General Test Conditions

The test began in 1968.

Installation was at the Thirty Slope Mine Inc., Four Foot Skidmore Vein, located near St. Clair, Pennsylvania.

The monorail system is manufactured by Scharf GmbH in Hamm, West Germany. The conventional I-Beam was suspended by roof anchorage.

Roof bolts - 42" x 3/4"
I-Beam - 2-1/2" x 5-1/2" (103 pound per ten foot length)
Drive Motor - 80 HP
Speed - 600 fps
Length - 1600 feet

The system can follow turns, arcs, and curves of reasonable radii. It is driven by means of an endless rope. The monorail was installed in the mine slope.

A six car train was used (18 tons total).

Engineering, research and evaluation sponsor was the former Pennsylvania Coal Research Board, an agency of the former Pennsylvania Department of Mines and Mineral Industries (now Department of Environmental Resources).

C.12.b Advantages

Track and roadway maintenance are eliminated as governing factors in the transportation system.

The monorail system car can be either floor or roof mounted, both of which can be installed, advanced, or retreated with ease.

The owner believed that it would be possible for one man to control operations from loading to dumping with the use of closed circuit television.

---

[1] "Suspended Monorail System Provides Effective Haulage", Coal Mining and Processing, July 1969, p.38.

[2] S. Oguz and R. Stefanko, Evaluation of a Monorail Mine Haulage System, The Pennsylvania State University, SR-78, February 1, 1971.

Monorail gives overall dependable service and ease of hauling coal, supply handling, or riding men.

C.12.c Limitations

Lateral forces are exerted if the haulage rope is not run parallel to the monorail.

Stable roof conditions are necessary.

C.12.d Conclusions

Monorail systems are expected to take their place in similar installations, both in anthracite and bituminous.

The next installation of this experimental system was intended to be an actual production cycle in a mine with thicker eight to twelve foot veins (Buck Mountain Vein) using a 26 car train on a 4,600 foot run. (However, it was later reported that, for various reasons, this was not done).

C.13 Hydraulic Coal Mining[1]

C.13.a General Test Conditions

The tests of a hydraulic mining system in bituminous coal were conducted in the Pittsburgh Seam, which averaged 66 inches thick. The site was a drift mine near West Lebanon, Pennsylvania.

The purpose of the tests was to evaluate the ability to mine coal using a solid water jet. A 900 HP pump was developed to deliver 300 gpm at 4000 psi. Operators had no previous experience.

The operator was protected from flying coal by a three-quarter inch multiplate glass shield.

Nozzles were set six inches from the face, then the water pressure, jet duration period, and cutting angle were varied to determine net results.

Tests determined that 4000 psi will mine bituminous coal effectively, using 30 second jet intervals, to a 48 inch depth. (Each test lasted two minutes and cuts were measured at ten second intervals).

---

[1]J. J. Wallace, G. C. Price, and M. J. Ackerman, Hydraulic Coal Mining Research: Equipment and Preliminary Tests, U. S. Bureau of Mines, RI 5915, 1961.

C.13.b Advantages

Hydraulic mining appears to increase production over conventional methods.

In gassy mines, the system has a distinct advantage over conventional methods.

At least in this test it was determined that mine drainage water can be utilized to supply water for pumping (pH 3.4).

The deepest 30 second penetration was 74 inches with a three-eighths inch 2D nozzle at 4000 psi.

C.13.c Limitations

Tungsten carbide lined nozzles failed at 3000 psi and were replaced with high-grade steel.

One-half inch diameter nozzles failed to reach operating pressures.

Bony material near the bottom influenced the undercutting rate. The more homogeneous the material, the better the cut.

If the bed dips toward the face, water collects at the undercut and forms an energy diminishing dam.

Operator training is a necessity. The jet stream must be moved at a fixed rate which will give optimum cutting. Operator visibility is diminished by water vapor and spray.

Loading the material must be solved. The fine coals were compacted by the slurry and could not be mechanically loaded.

C.13.d Conclusions

The coal can be mined at high water pressures.

There is an optimum size nozzle for each operating pressure. The one-quarter inch and three-eighth inch nozzle displayed their best results when mining was limited to four foot advances.

Mining production decreases as the distance from the nozzle to the face increases.

A method for recovering fines while they are still in a slurry state must be designed.

C.14 Hydraulic Mining of Anthracite: Engineering Development Studies[1]

C.14.a General Test Conditions

Hydraulic testing commenced in 1958.

The hydraulic "jumbo" was designed for maneuvering on pitches of zero to 20 degrees in any direction. The coalbed thickness ranged from ten feet six inches to 15 feet.

The Bottom Red Ash Bed of the Sugar Notch mine (former) Glen Alden Coal Company, Sugar Notch, Pennsylvania, was selected as the test area. Also considered in this determination was proximity to electrical power, water supply, existing mine openings, and location where first mining could be done.

Refuse bands consist of sand rocks and sand slates. The top coal varies in thickness, while the bottom bench of denser coal increases with bed thickness up to seven feet.

A vertical, nine-plunger, positive-displacement pump was used in the study. It was designed to deliver a capacity and working pressure of 300 gpm and 5,000 psi, respectively.

Synchronous Motor - 1,000 HP, 2,300 volt AC
Speed - 300 rpm

The pump was installed on the surface using fresh water from a utility main.

Weight of the hydraulic "jumbo" was eight tons.

C.14.b Advantages

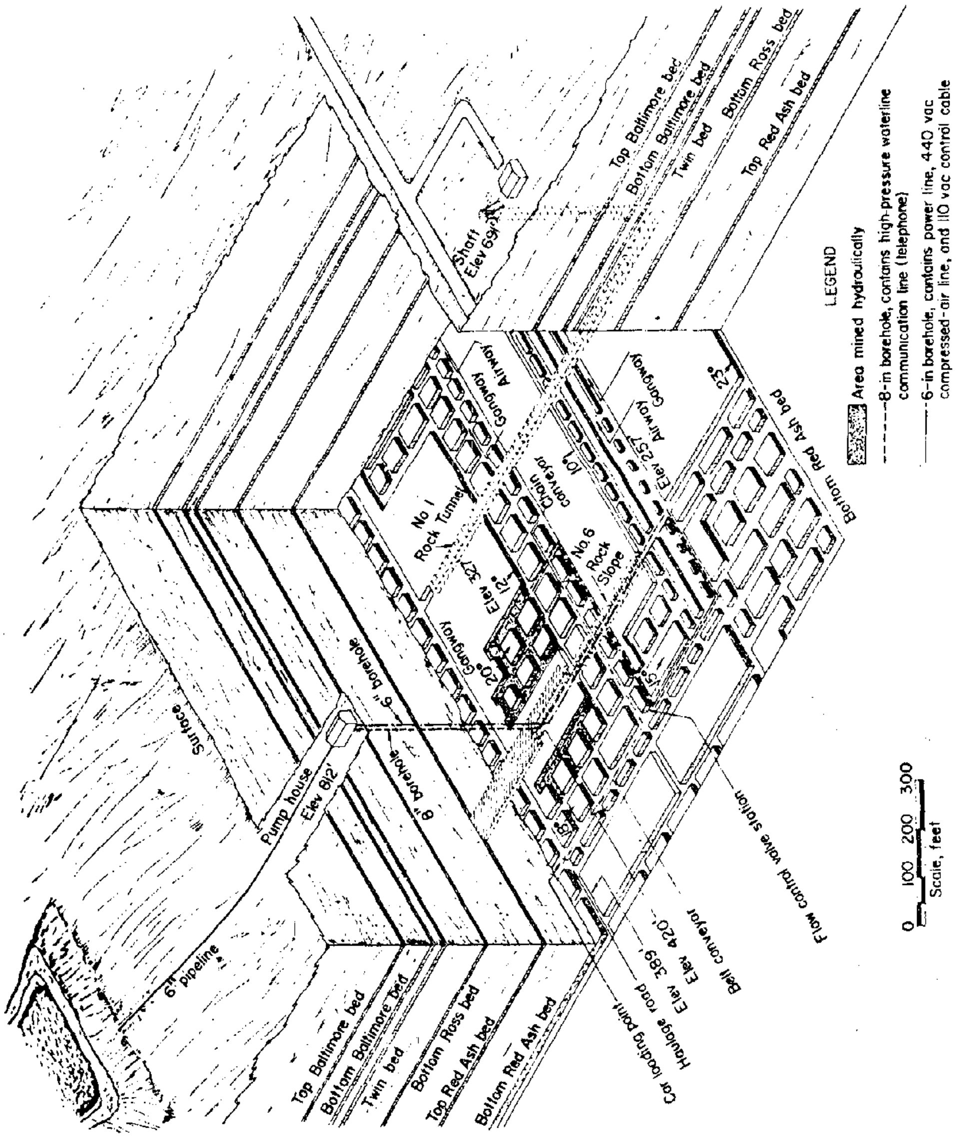
Hydraulic mining is considered to be the most efficient method used in beds pitching enough for the face to be cleared of broken materials by gravity.

With hydraulic mining, airborne dust is not present.

---

[1]John W. Buch, Hydraulic Mining of Anthracite: Engineering Development Studies, U. S. Bureau of Mines, RI 6610, 1965.

HYDRAULIC MINING INSTALLATION



SOURCE: Bureau of Mines Report of Investigations 6610

PLATE V - 15

It was noted that the jet pressurized areas into disintegration instead of through knife-like cutting. This characteristic is important in mining anthracite with hard bands of refuse material.

The use of explosives is eliminated, removing the hazards caused by blasting.

C.14.c Limitations

Although fresh water was supplied in this experiment, the effect on the high-pressure pumping system by the use of acid mine water might be an economic limitation due to corrosive effects. (This limitation on the use of mine water remains to be proven).

There was a problem of removing material broken up by the jet stream while the "jumbo" continued to operate. However, no special device was warranted until the hydraulic mining method could be proven.

It is necessary to position the jumbo mast three times for a 20 foot face. However, for a full advance, the undercarriage needs only to be positioned once in the center of the chamber.

C.14.d Conclusions

Chambers and crossouts were mined out at the following average rates respectively: 0.821 ton per minute and 0.714 ton per minute. Power requirements averaged 13.2 Kwh per ton for chamber mining and 16.2 Kwh per ton for crosscuts.

The effect of water infusion is to be investigated as a means of increasing the production rate.

Hydraulic mining is considered to be the most efficient method used in beds pitching enough for the face to be cleaned of broken materials by gravity.

Economical, highly-productive mining systems must be developed. A total hydraulic system of mining, transportation and hoisting might be the answer.

C.15 Hydraulic Mining Operations and Infusion Tests[1]

C.15.a General Test Conditions

The evaluation was performed within the Northern Field in the Bottom Red Ash Bed, No.1 Tunnel East, Sugar Notch Mine, owned by the Blue Coal Corporation. The vein is 13 to 15 feet thick and pitches ten to 20 degrees.

The equipment used was a stationary hydraulic "jumbo" utilizing a telescopic nozzle mounted on swivel joints. The experiments were performed using water with:

Pressure	3000	-	5000	psi
Discharge	200	-	300	gpm
Jet traverse	4	-	44	ips

Sixty-four separate tests were performed in order to evaluate a selection of variables by computer and to determine the relative effects of these variables on a mining rate.

Water infusion tests were also performed to determine elimination of dust primarily, and, as a secondary function, partial degassing of the working face. To provide even distribution of water through the coal, holes were drilled 13 to 18 feet deep.

C.15.b Advantages

A jet stream will fracture and dislodge material from a solid face with virtual absence of dust or ignition sources in an explosive atmosphere.

An integral hydraulic system of mining and transporting materials on moderate to heavy pitches appears to offer a potentially productive system both from a safety and economical viewpoint.

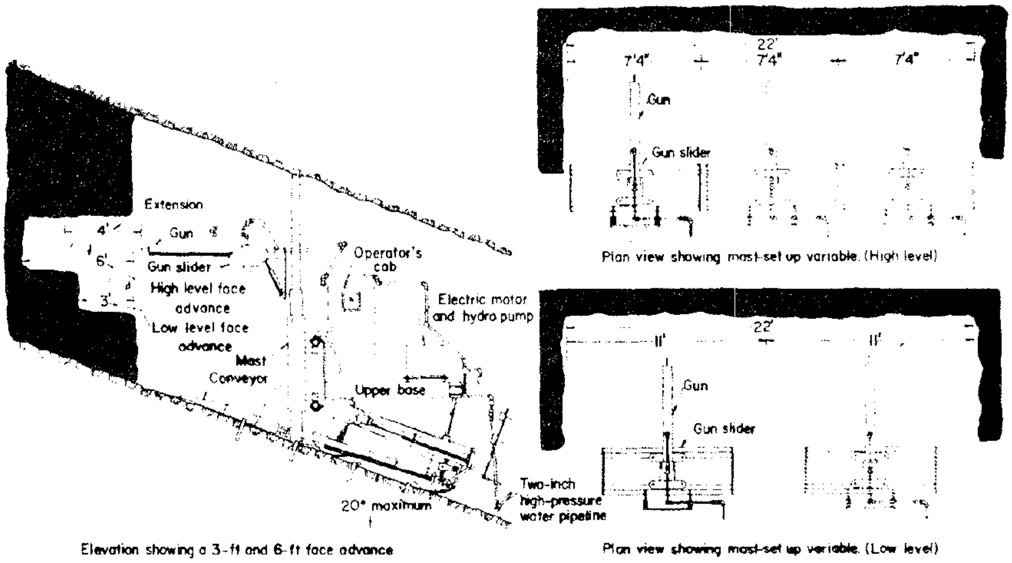
The hydraulic jumbo was flexible with respect to operational settings concerning nozzle pressures, water volumes, jet traverse, and to some extent nozzle diameter. The most important factors were found to be pressure-volume, pattern and jet traverse speed.

Greater latitude in future equipment design is possible since factors which were found not to be significant included mast setups (positioning equipment), face advance and jet impact angle.

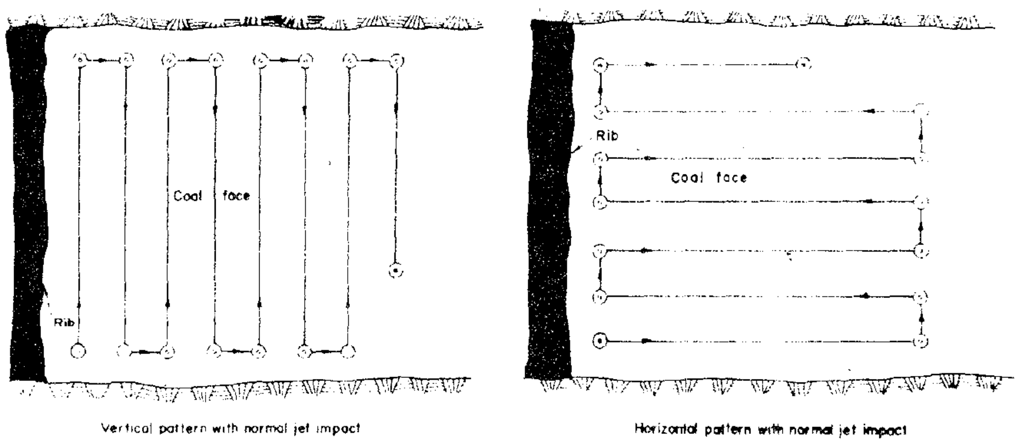
---

[1]Wilbert T. Malenka, Hydraulic Mining of Anthracite, Analysis of Operating Variables, U. S. Bureau of Mines, RI 7120, 1968.

HYDRAULIC MINING
(ANALYSIS OF OPERATING VARIABLES)



Face Advance and Mast Setup Variables.



Face Pattern Variable.

SOURCE: Bureau of Mines Report of Investigations 7120

PLATE V - 16

The coal was mined at rates which varied from 0.3 tons/minute to nearly 1.4 tons/minute depending upon the test parameters. The standard average was considered to be 0.952 tons/minute.

C.15.c Limitations

The test vehicle was relatively immobile.

It was uncoordinated in that it depended on the telescopic nozzle in conjunction with swivels to complete a jetting pattern.

Debris and excess water at the face was a continuing problem.

In coalbeds 13 to 15 feet thick, an infusion test prior to hydraulic mining aggravated the already hazardous condition of falls along the roof and ribs, causing falls of increasing frequency.

C.15.d Conclusions

Coal extraction by hydraulic mining in anthracite appears feasible if the equipment size, mobility, and performance can be adapted from the lessons learned in this and other tests.

Roof supports used with hydraulic mining must be developed which are compatible with the requirements necessary for safe operation of the "jumbo".

Better control methods for handling water and debris in front of the jumbo must be established. Perhaps hydraulic mining would be more applicable to steeper pitches where the coal would "run" from the face.

A horizontal pattern was found to be more effective than a vertical pattern, probably due to bedding planes and stratification of rock lying in a horizontal plane.

Jet traverse speeds in excess of 44 ips would probably further increase the mining rate.

Additional evaluation of water infusion methods are needed. Infusion at 100 psi gave no reason to expect better mining rates than without infusion. Pressures of 800 psi might prove effective in areas where slips are not prevalent.

C.16 Development Mining in a Steeply Pitching Coalbed, Roslyn, Washington[1]

C.16.a General Test Conditions

The hydraulic mining machine comprised a remote control system and a monitor mounted on a self-advancing hydraulic roof support unit of the type commonly used on a longwall face.

The overburden consisted mainly of sandstone, while the floor was sandy shale.

The test was conducted at the Roslyn No.10 mine, Northern Pacific Railway Company, Roslyn, Washington.

The purpose of the investigation was to evaluate the feasibility of hydraulic mining on steep pitches.

A triplex, single acting, horizontal plunger pump was used:

300 gpm
4000 psi
800 HP electric motor

C.16.b Advantages

The use of exposives is eliminated, removing the hazards caused by blasting.

Through the use of hydraulic hose, the operator can control the process to a maximum distance (60 feet) from the face.

Face dust and electrical equipment are reduced in hydraulic mining.

Productivity is increased during hydraulic mining of pillars after first mining.

C.16.c Limitations

The productivity of hydraulic mining was 2.8 and 3.3 tons per man less than conventional hand mining for raise and room mining, respectively.

---

[1]George C. Price and Frank Badda, Hydraulic Coal Mining Research, "Development Mining in a Steeply Pitching Coalbed, Roslyn, Washington", U. S. Bureau of Mines, RI 6685, 1965.

In development, hydraulic mining is considerably less productive than conventional mining methods.

During periods of high extraction rates, large lumps of coal could not pass through the bulkhead of the chute.

The main problem of hydraulic mining in steeply pitching coalbeds is developing a monitor mounting.

C.16.d Conclusions

Hydraulic mining is best suited to veins in excess of 15 degrees pitch where natural pitch can be used to transport the coal.

Economically speaking, the experiment was unsuccessful because the productivity for conventional methods was higher than the hydraulic mining. However, productivity was satisfactory for a development test, and a machine was developed for use on steep slopes.

Areas to be improved are methods of roof support, transportation, and the handling of supplies.

The self-advancing roof support unit was practical and effective in mounting the monitor in steeply pitched beds. The unit could be developed further to increase its mobility.

C.17 Hydraulic Transport of Coal[1]

C.17.a General Test Conditions

The objective of this experiment was to study those factors affecting the transportation of a coal-water mix through a centrifugal pump and pipeline, e.g. flow characteristics, pressure drop, size distribution, and degradation of coal.

Bituminous lump coal (minus two inch - Pittsburgh Seam) was used in concentrations up to 48 weight-percent.

A pipeline arbitrarily chosen as three times the top size of coal, or six inches, was used in the test.

---

[1]Arnold P. Pipilen, Murray Weintraub, and A. A. Orning, Hydraulic Transport of Coal, U. S. Bureau of Mines, RI 6743, 1966.

C.17.b Advantages

Hydraulic transportation reduces the number of injuries that occur during coal haulage by mechanized transporters.

There is also a reduction in coal dust hazards by using hydraulic transport.

There are possible economic advantages if water needs to be pumped from the mine site or in conjunction with hydraulic mining.

C.17.c Limitations

There is a problem of coal size degradation for bituminous coal, caused by damage in the pump and abrasion in the pipeline. Degradation was increased in the pump by higher rotative speed, and decreased by higher linear flow rates. Degradation has an effect on its marketability, depending on the importance of size to the consumer.

The flow rate is very sensitive to coal concentration and the density of solids.

In a special test the high density particles, comparable to high ash coals (specific gravity 1.8 instead of normal 1.3), had a velocity 85 - 90 percent of the lower density particles.

C.17.d Conclusions

An optimum concentration of 36 percent by weight was found to deliver the most coal in the system investigated.

A similar but different optimum was found to minimize the energy requirement to move a ton of coal.

A system of recording sound intensities was developed for determining flow and segregation patterns present in the coal-water system.

In this test it was determined that a maximum rate of 70 - 80 tons per hour of coal is possible through a six inch diameter pipe.

D. ALTERNATIVE METHODS OF WINNING ANTHRACITE

D.1 Introduction

Plate III-2 shows that, by 1990, some 57 million tons of coal have to be mined from sources other than present operations. From that date on, nine million tons a year of this "new" coal is predicted, giving a running total, from 1975, of 147 million by 2000, 237 million by 2010, and so on.

The next three sections of this Chapter postulate three different possibilities for recovering coal reserves - that all mining will be done by conventional surface mining, all by deep stripping, or all by deep mining. The purpose of studying these alternatives (or "scenarios", to use a currently popular term) is to analyze the possibilities of any one method alone providing all the increase in production (new coal) for the foreseeable future (25 to 50 years), and so determine where research and development effort may most effectively be applied. All alternatives assume that the market projections will be attained and that markets will be assured.

D.2 First Alternative - Conventional Surface Mining (Stripping)

By surface, or strip, mining is meant the recovery of coal by first removing the overburden then excavating the seam. Such operations in the Anthracite Region today are usually limited to about 150 foot depth, although some operations are considerably deeper than this. Current production by this method is approximately 3.2 million tons a year.

Estimates of strip mine reserves for a specific operator are difficult to analyze. Most operators have "reserves" in view for seven to ten years, but these reserves tend to go up as the sale price increases. There are few virgin areas left for stripping, although there are previously worked properties that are available for sale or lease.

Areas previously deep mined are often marginal for strip mining. Debris is mixed with the excavated seams, and other portions of the vein are lost in the open breasts when strip mining the pillars. The result is that the operator in, for example, an area that was 50 percent deep mined, usually gets only 40 to 45 percent recovery through the breaker. As a result of an improved market and corresponding price increases, these marginal pits are now being reopened. The same situation holds true for the thinner seams, areas having elevated ground water tables and seams with greater overburden ratios.

In the above type of extraction, the operator may confine his draglines and/or shovels to sizes from five cubic yards to 18 cubic yards. One large operator with this type of equipment is doing "second" stripping at a depth of 130 feet from the existing ground surface in areas that were deep mined many years ago, excavating the first 40 feet by shovel and the next 90 feet by dragline.

Other areas being surface mined are relatively flat synclinal basins. With favorable economic ratios entire basins of coal can be removed, approaching 100 percent extraction. The result is more like the "area" mining in bituminous coal, rather than strip mining or "contour" mining. Sometimes these basins will not have been deep mined due to poor roof conditions, a situation that can be ideal for surface mining with large front-end loaders and trucks; however, these sites are the exception rather than the rule.

Strip mining of deeper basins is now being conducted, usually in the thick Mammoth Vein. Some of these operations are down to depths in excess of 400 to 600 feet. Usually, electric walker draglines are used with bucket sizes ranging up to 85 cubic yards. These operations are quite large and will extend for many years. Two such operations are the Jeddo Stripping, mined by the Jeddo Highland Coal Company, and the Greenwood Stripping in Panther Valley (east of Tamaqua). The former has an estimated life in excess of 20 years or more. The latter was recently sold to the Bethlehem Steel Company and reportedly has total reserves of 150,000,000 tons.

The availability of large tonnages of anthracite reserves will depend, not so much on planned rates of extraction, but on the surface use of the land. The development of residential communities, shopping centers, and industrial parks beyond town limits, will discourage any attempt to mine within these built-up areas. As this growth continues, local zoning ordinances will increasingly reflect the attitudes of the inhabitants. Even today, a considerable amount of strippable coal is unmined due to being located in developed areas.

State Game Land purchases in recent years have also encroached substantially on potential anthracite producing areas. Attempts to obtain permission to mine these areas have not been successful.

Another consideration is that the diverse ownership of surface and mineral properties discourages the necessary large scale planning and the investment capital that will be required for assembling sizeable blocks of land.

It has been calculated in Chapter IV that there are approximately 993 million tons of "strippable" coal remaining in the Region. Assuming 60 percent of this is under towns or otherwise cannot be feasibly strip mined, then 400 million tons is a practical recovery figure. Again, this figure allows for maintaining much the same production methods as today. Should it prove feasible to strip mine much deeper than at present, and still remain economically competitive, then the "strippable" reserves could be considerably more than the 993 million tons.

Without any appreciable change in the three million tons per year production from culm and refuse banks, stripping would have to increase to 14 million tons a year to meet the projected demand of 17 million tons a year in the 1990's, if there were no deep mining. As Table III-2 shows, it will take some years to build up this demand, and the 400 million tons, allowing for losses in the preparation process, should be sufficient until about the year 2000 without any dramatic improvement in recovery methods.

In expanding production to this scale, many of the smaller strip areas will become exhausted and operators will be forced to buy or lease additional acreage.

Even though the industry supply has not met the demand of the last few years, few operators have expanded their operations. In view of the market uncertainties they are cautious of investing heavily in new equipment and prefer to increase the operating time of their present equipment. The six day week is common, and the larger draglines are on three shifts. Smaller equipment may operate on one to two shifts per day.

Before there can be an expansion of the surface mine industry, confidence has to be restored. A 28 cubic yard dragline that cost $1,800,000 several years ago now costs $4,500,000. Only the large metropolitan banks can finance this type of transaction and they show a reluctance to fund what may be a "dying" industry. An operator may have to pay five points over prime rate to obtain a loan, and will understandably be reluctant to do so. However, smaller equipment, such as bulldozers, trucks and front-end loaders, are more easily financed by local banks.

It is interesting to note that some surface mine operators state that little governmental research and development is needed for equipment, as most of the equipment developed for the large bituminous surface mining industry can be applied to the anthracite fields. Development of some auxiliary equipment may be required. For example, one operator reported a problem with trailing cables from electrified equipment. Development of economical protection methods are needed from the standpoint of safety.

One problem encountered in heavy sandstone and conglomerate overburdens results from inconsistent fragmentation. Large pieces of rock require a considerable amount of unproductive time to handle with the equipment normally used in the smaller stripping operations.

Anthracite strip mining costs might be reduced by applying techniques and equipment (as discussed below) used in Western coal and ore mining. Some of this equipment might require modification for use in the Anthracite Region.

Conventional surface mining could, therefore, meet the demands for anthracite for the next 25 years. The technology of extraction exists. Some solutions to problems discussed earlier include: reduction in pumping costs, restoration of confidence by establishing a steady demand, some help in financing by guaranteeing loans, an understanding by local governments of the need to win this coal and their cooperation by appropriate planning and zoning, and cooperation by the State and Federal Governments in applying the environmental and reclamation regulations with reason.

None of these are insurmountable, and conventional stripping is a viable alternative until the year 2000.

D.3 Second Alternative - Deep Surface, or Deep Pit, Mining

Deep pit mining involves the taking of a large area of land and systematically removing all the coal, by surface mining methods, down to a depth of maybe 2,000 feet. It will be apparent that this method differs from conventional anthracite surface mining in the tremendous amounts of overburden that have to be removed and, eventually, replaced, as well as the complete disruption of the area being mined.

The Pennsylvania State University currently has a contract with a group of electric utility companies to study this concept in the Anthracite Region and to determine its feasibility. It is understood that the report is due to be published in May, 1975.

The discussion that follows reflects the observations of this Consultant, and should be regarded as an interim statement pending the results of the much more thorough Pennsylvania State University study.

As a first step in the area of research needs, a detailed documentation of seam thicknesses at depth is essential. Despite over 200 years of mining activity and the competent studies of the State and Federal Geological Surveys, very little definitive information is available on the broad, deep basins of the Southern and Western Middle Fields, where the greatest concentrations of reserves are found.

Although some shallow drilling logs can be recovered from old records, the dips in a typical syncline are normally projected from the known dips of past mining. The assumption is made that these dips then intersect at depths of as much as 3000 to 5000 feet. The thickness of the vein at this depth adds to the unknown. There is some indication, based on past experience in shallower mining, that the thickness of the coal in the bowl of synclines may be greater than in the flanks.

Estimates based on projections and conjecture will not allow the planning of large scale deep pit projects; a program of deep exploratory drilling will identify areas for future development. This deep drilling is very expensive, and could be one form of assistance to the industry, perhaps through the State and Federal Geological Surveys.

Further research is needed in rock mechanics, especially as it applies to slope stability and safety. The stabilization of pit walls, necessary for the protection of men and machinery, may require the removal of inordinate amounts of material beyond the pit area. The possible effects of pinning or bolting should be investigated. The safety benefits are obvious.

In most strip mining, the initial financial burden is high since no coal is extracted for a considerable period of time. These costs would be greatly magnified in deep pit mining, as will the reclamation costs for the entire pit.

Another problem of some magnitude would be that of water, with the attendant costs of pumping and treatment. One form of assistance might be the state/federal pumps which were supplied to the industry some years ago.

Perhaps the greatest problem might be sociological. The movement of people, dwellings, roads, trees, fields and so forth will have a tremendous impact on the lives of the inhabitants.

The ideal situation would be coal veins of significant thickness intercepted about every 75 to 100 feet of depth, so that economic ratios of overburden to coal hold as the mine is developed to greater depths. The resulting pit would resemble an ore mine in the West, with benching at each vein intercept.

The parallel to the deep stripping being conducted in West Germany is frequently mentioned. However, there are several very important differences. At the West German sites they have an easily excavated friable overburden and lignite deposits that are 150 to 200 feet thick.[1] In the Anthracite Region much of the overburden material is a conglomerate or dense sandstone which is extremely hard on equipment and costly to drill and shoot.

Equipment now in use or under development for the massive excavation of western coals possibly can be applied or adapted to large scale anthracite deep pit mining.

Recent increases in shovel sizes have led to the development of lightweight aluminum booms. Gas filled tubular booms, in triangular form, allow reduced weights and immediate warning of structural defects. Faster cycling times, longer reach and reduced maintenance are cited. Improvements are being made in electrical power transmission and control. Hoist and crowd mechanisms have been redesigned to operate more smoothly and accurately. Improvements in metallurgy and design have increased bucket strengths. Sophisticated alloys in all components of the system have led to lower maintenance and increased operating life.

Off-highway trucks, having capacities of 240 tons, are now being manufactured, and would be required to move material much further than in conventional stripping. Increased use of high-strength aluminum alloys has improved operating efficiencies and capacities. Power trains have been strengthened while greater attention is being concentrated on electric wheel drives.

Wheel mounted front-end loaders, with capacities of 24 cubic yards, are operating today in some areas of the United States. Designers envision the

---

[1] "The Surface Mining of Coal", Energy Perspectives, Battelle Memorial Institute, March, 1974.

use of 50 cubic yard machines in the foreseeable future. The problems of low tire life and cutting blade wear are being solved. More frequent use is being made of the loader as a primary tool for overburden removal. Shovels with innovative front-end geometry are being produced which incorporate the break-out advantages of the loader with the strength and fast cycle time of the shovel.

Rotary drills are capable of 17 inch diameter holes, with automated controls sensing and responding to changing rock characteristics. Stem lengths of over 50 feet and loading pressures in excess of 100,000 pounds are being used.

The relatively cheap but effective blasting agents of today are under constant improvement. Ammonium nitrate-fuel oil (ANFO) mixtures and newly developed primers are in common use. Metal and gelatin slurries are improving at a rapid pace and may ultimately provide the degree of fragmentation necessary for an automated earth moving system.

The development of the bucket wheel excavator holds some promise for improving overburden removal costs. Performance figures of 13,000 cubic yards per hour are reported. Because of structural deficiencies, present designs restrict its use to softer overburdens. A redesigned support structure and an improved conveying system could result in a reduced cost for anthracite overburden removal.

Dozers are being manufactured in the seventy-five ton, 800 horsepower range. Equipped with blades measuring twenty-four feet in width, a significant reduction in reclamation costs can be expected.

Belt conveyors having capacities of over 100,000 tons per day are in use. Widths of 60 inches can be ordered from stock.

Pit sited portable crushers are available up to 700 tons per hour.

Counter balanced skip hauling systems for deep pits are in use at many open-pit metal mines. Using 40 ton cars, capacities of 60,000 tons per day are reported.

Scrapers are built to load 360 tons of material in one and a half minutes, without a pusher. These machines develop over 5,000 horsepower and ride on tires ten feet in diameter.

It would appear, therefore, that the technology exists or is being developed to mine on this scale. Apart from the sociological problems already mentioned, there are those of organization and finance. Companies or consortiums must be formed that can handle the enormous amount of earthmoving, and they must be adequately financed, especially to cover the development stages prior to recovering any coal.

Such a program for just one area could be expected to yield all the "new" coal required for several decades.

This method of winning coal has an attractive potential. A comparatively shallow basin could be mined out once and for all, and the land restored. The present problems of waste piles, acid mine drainage, and the general blight of most of the region would be removed and attractive towns and recreation areas could result. Deep pit mining should not be regarded solely as a method of mining coal but as a great opportunity for planning and redevelopment.

In addition to proving the economic viability there will undoubtedly be need for extensive ecological, sociological and legal studies into the effects of mining at this scale. These needs will be better identified by the Pennsylvania State University study.

D.4 THIRD ALTERNATIVE - DEEP MINING

Deep mining may be defined as mining performed underground, and includes drift, slope and shaft mines.

There have been many developments and improvements in underground mine extraction equipment and methods since the tests reported previously in this Chapter, and the following is a discussion of several recent and promising mining systems which may be applicable to anthracite coal mining.

D.4.a Continuous Mining Machines

Continuous mining machines can be divided into two broad classes, "rippers" and "borers". Their use eliminates the cutting, drilling and shooting cycle required by more conventional mining methods. Rippers are equipped with coal cutting bits or picks and operate either perpendicular or parallel to the face. Borers are advanced into the face by defining a circular pattern of grooves.

A continuous mining system was used successfully on an economical production basis to mine anthracite coal. However, all work was in the Northern Field where the relatively level basins allowed room and pillar mining, closely resembling bituminous coal mining. It is reported that the Glen Alden Company experimented with different machines between 1957 and 1966. Some of the most successful equipment included:

2	Joy 4 JCM Continuous Miners
2	Joy 10 RU Universal Cutters
7	Jeffrey 70 UR Universal Cutters
1	Goodman 2410 Universal Cutters
34	Joy 8 BUT Loading Machines
11	Joy 9 SE Shuttle Cars (Rubber tired)

13 Joy 10 SE Shuttle Cars (Rubber tired)
4 Torkar Shuttle Cars (Rubber tired)

After the initial period of experimentation, the most economically productive period was 1962 - 1963 when 1,600,000 tons of anthracite were produced at a prepared cost of $5.88 per ton. The limiting slope for this equipment was twelve degrees. Since there was a hard floor, rubber tired shuttle cars worked best. Due to increasing water problems, the work was suspended in 1966.

In 1968, another attempt was made to evaluate a shortwall continuous mining system in an anthracite mine (see p.V-20). The experiment was performed under the most adverse conditions and experienced difficulties with local mine water impoundments, pyritic intrusions, undulating roof and high dust levels, and was consequently terminated.

It should be recognized that continuous mining machines have limitations, especially when applied to pitching seams. Except on an experimental basis, none has ever been used in an anthracite mine. It is apparent that available continuous mining equipment cannot meet all the requirements for an anthracite application. There are, however, machines which can be adapted for specialized uses.

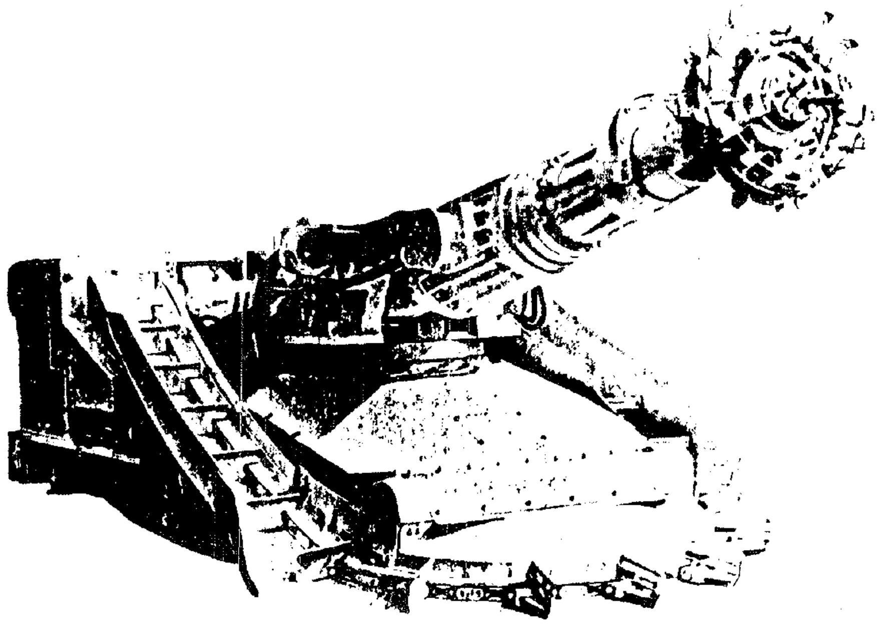
1. Roadheader

The roadheader is relatively new to the United States market and most of the machines are currently imported from European sources. They are normally crawler mounted, with a ranging boom, weight from eleven to 34 tons and have the ability to mine an area from four feet up to twelve feet high and as wide as 15 feet by means of an articulated boom. The machines are a more powerful type than that used in the 1969 ranging drum-shearer tests. They normally develop 150 to 230 horsepower, and utilize a ripper-type cutter which reportedly will break through rock up to 18,000 psi compressive strength. Production rates are given of 15 to 30 cubic yard/hour in rock and 35 to 70 cubic yard/hour in coal. The factory cost of the machine is in the $160,000 to $250,000 range.

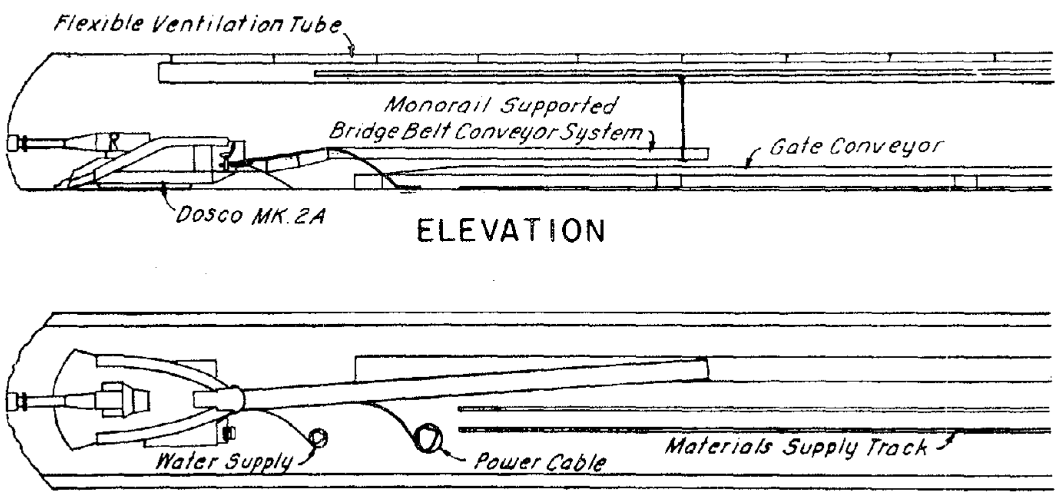
Manufacturers of these systems claim that because of the ranging boom the miner displays greater flexibility. It can be used as a tunneling machine (eliminating blasting) in soft to medium-hard rock, and can be used for shortwall, room-and-pillar, or stope mining methods. Slopes up to 20 degrees (35 percent) are within the system's current capabilities.

To modify the roadheader for optimum use in anthracite, a method for mining on slopes at least to 45 degrees should be developed, and with the capability of cutting harder rock when necessary. Such a

ROADHEADER



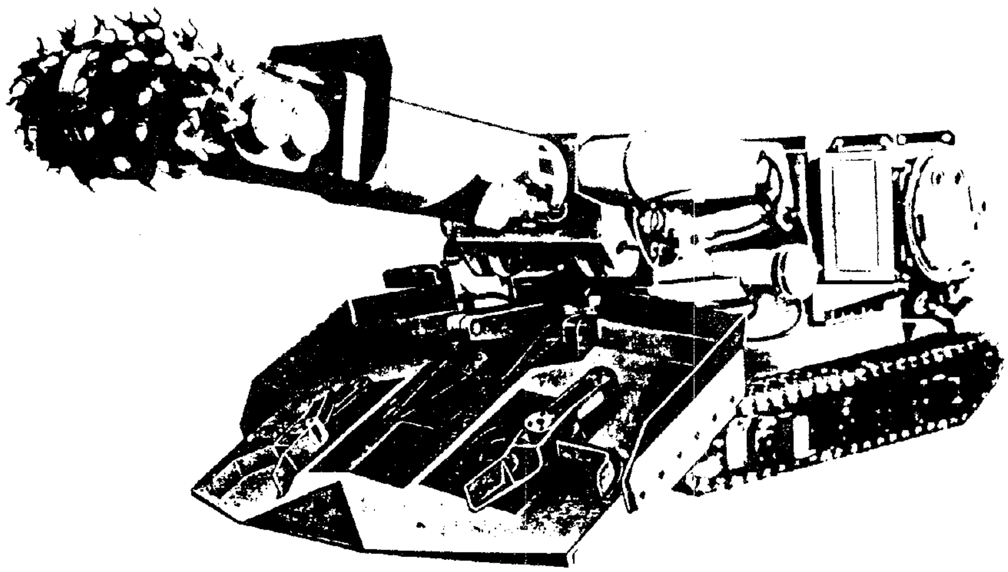
DOSCO MODEL MK.2A



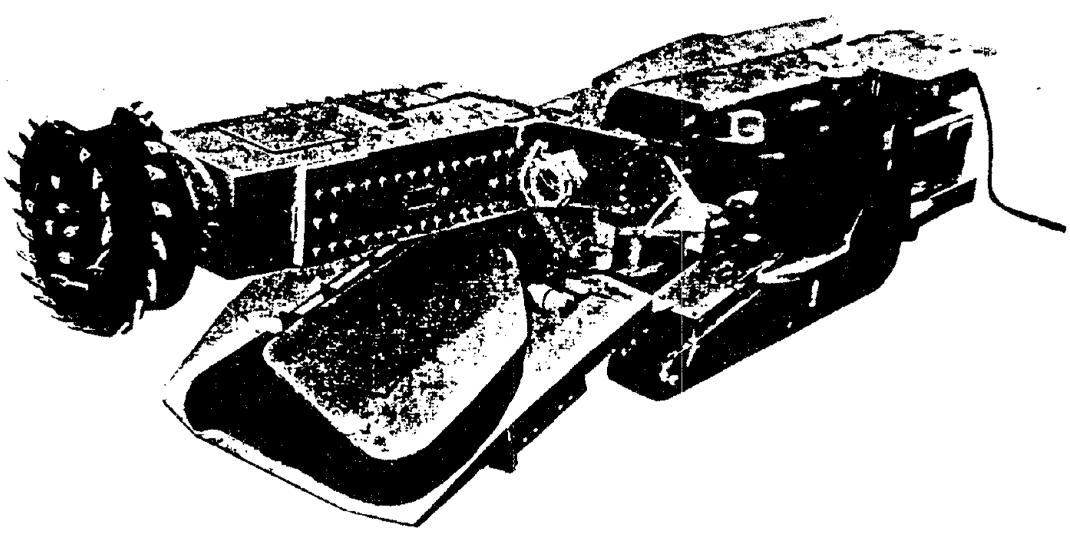
SOURCE: Courtesy of The Dosco Corporation

PLATE V - 17

ROADHEADERS



ALPINE MODEL AM-50



ANDERSON MAVOR "BOOM MINER"

SOURCE: Courtesy of Alpine Equipment Corp. & Anderson Mavor Limited.

PLATE V - 18

machine should establish the desired economies for removing coal from moderately pitched, medium-thick veins.

Since dust suppression is needed anyway, one intriguing idea is being developed in the West to combine hydraulic monitors with the roadheader to cut slots in the coal.

2. Continuous Arc Miner

A continuous arc type miner has been used in recent years in the bituminous industry for mining thin veins (24 to 48 inches). The system normally consists of two augers which are mounted in parallel and driven by separate motors (up to 100 horsepower each). The machine is pivoted across the face by alternating tension to a system of ropes which are connected to anchor jacks located on either side of the room. Coal is recovered by means of conveyors, and the resulting production has normally been in the 100 ton per shift range.

The manufacturers of such machines have claimed that a significant advantage to their use is the fact that roof supports can be placed closer to the working face, fewer temporary supports are required, and that personnel are not required to expose themselves to unprotected roofs.

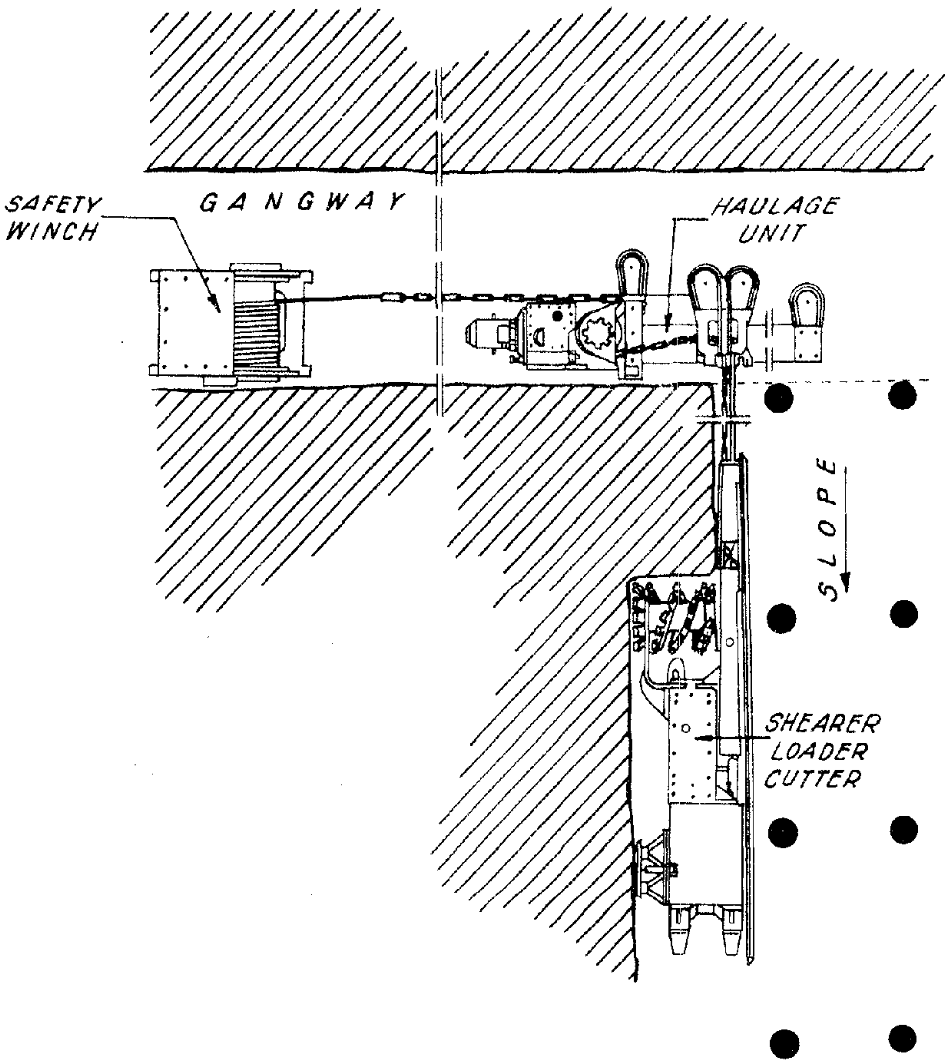
A system of this type has definite advantages to recovering thin seams along a synclinal axis and on slopes pitched ten to 15 degrees. No research has been done on steeper slopes to date; however, because of the continuous-arc miner's ability to hold its position by using self-contained pivoting jacks, its ability to pull itself up a medium pitched vein should be considered for further evaluation.

Again, a 100 horsepower motor may not be sufficient to cut through occasional pyritic seams or partings (even though one manufacturer stated that there had been no problems to date as a result of rock), and the cutting bits may require modification to improve their useful life in anthracite coal.

3. The Shearer Loader Combine

Mining the steeper veins, which incline 35 degrees, or more, has been a traditional problem with anthracite coal. The Polish Ministry of Fuels and Energy has developed a skid mounted shearer loader for mining thin-veined coal. This shearer is hoisted up the pitch by a system of pulleys and chains. As it is raised, the cutting drum, driven by an 80 horsepower motor, extracts a section of coal up to four feet thick. The coal then falls by gravity to a lower level, where it is collected by conveyor belts and transported to a mine car loading station. Timber props are used for roof support, and because

SHEARER LOADER COMBINE



SOURCE: "Coal Mining and Processing", August, 1969

PLATE V - 19

of the clean, front guide rail and hoisting assembly design, the miners are able to place props within twelve inches of the working face. Thus, after a pass has been completed, only five feet or less of exposed roof occurs at any one time.

A shearer loader of this type should warrant investigation in order to determine its benefits for mining the steeper veins. Because most Polish coal is bituminous or lignite and of a more friable nature, the machine would most likely require some modification in order to mine Pennsylvania anthracite. These changes would possibly include a more powerful shearing motor (150 HP or more), drum improvements to include cutting bits which will be resistant to pyritic seams and which will excavate rock when necessary, and hoisting revisions in order to comply with current health and safety regulations.

4. Impact Ripper

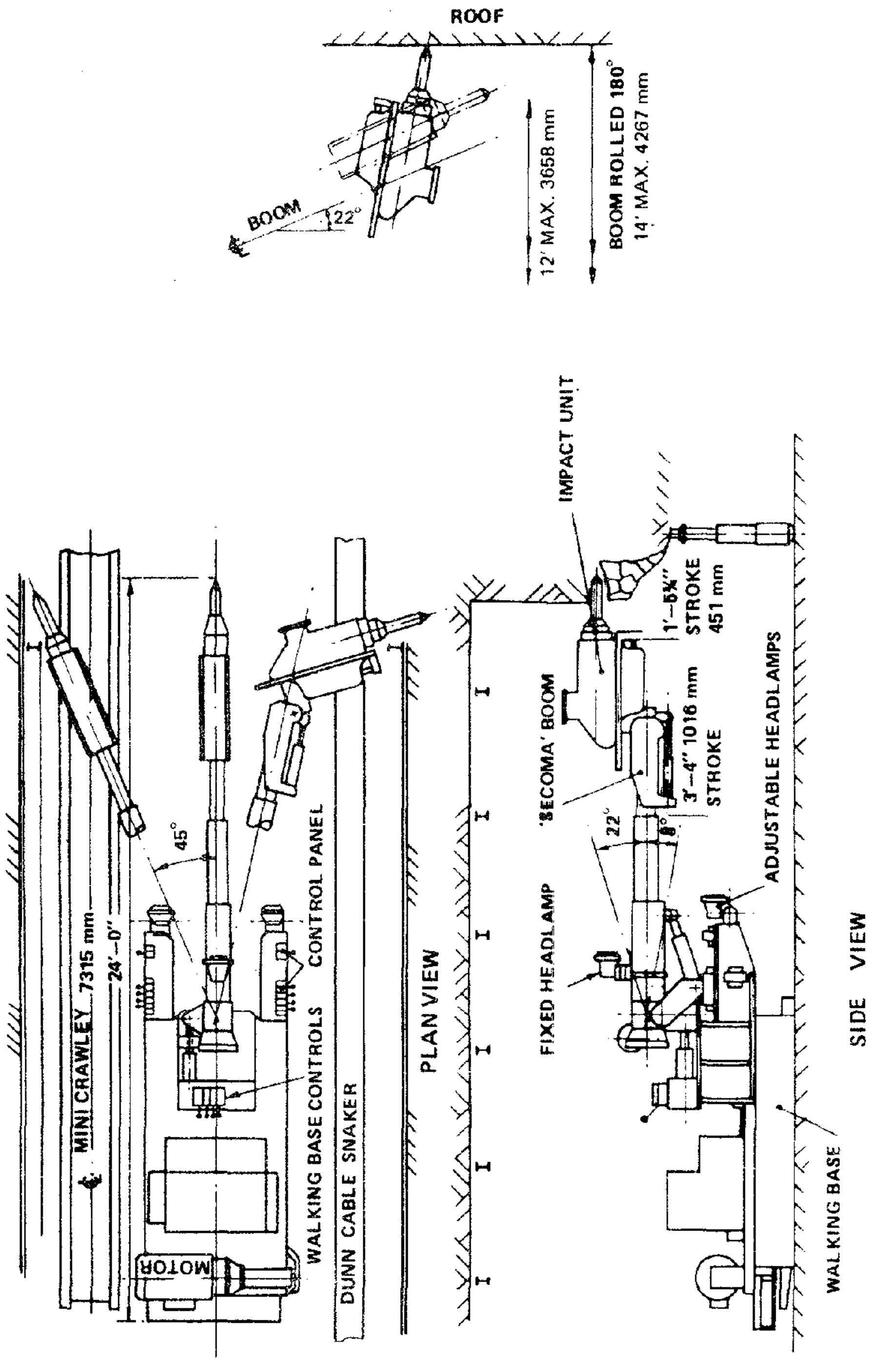
Rock tunneling is a major factor in the cost of deep mine developments, and with the concept of coal recovery approaching 100 percent, rock gangways below the coalbed with rock chutes to the vein are creating new interests. To supplement existing systems and methods for rock removal, Britain's National Coal Board, for one, has been investigating methods for breaking particularly hard rock strata. One of the resulting products is the impact ripper. The developers state that "It is designed to deliver a high-powered, high-speed chisel/ripping blow to the rock face."[1] This impact ripper is capable of being mounted on a variety of platforms and consists of a chisel assembly which is hydraulically impacted by a hammer-piston assembly, driving it into the face at several hundred blows per minute. The more promising machines develop from 1300 to 3000 foot-pounds of energy and have driven up to eleven feet of rock tunnel per shift. Rock blasting is eliminated as a tunneling method by using the impact ripper. The system apparently produces relatively small quantities of dust and sparking. The machine must be used in conjunction with, or be mounted on, a platform capable of removing the cut material.

The impact ripper can be used in winning coal both as a longwall and a shortwall continuous miner. For these applications the ripper is installed on a walking-type platform and the chisel is suitably modified for coal. Some of the systems are mounted on swivel heads and/or booms allowing for maximum maneuverability.

---

[1]D. Buntain, "British Experiment with Prototype Impact Ripping Machines", Coal Age, March 1974, pp.93-97.

IMPACT RIPPER



SOURCE: Courtesy of
Dosco Overseas Engineering Ltd.

PLATE V - 20

To date, the impact ripper has not been used in the anthracite industry. It is a tool that has been developed to overcome problems inherent in mining hard materials, and should be considered for evaluation as a supplementary mining system as both a shortwall continuous miner and as a machine for rapid development of rock gangways and tunnels.

5. Boring Machines

Auger mining is responsible for a significant part of bituminous production. Although the principle application is for the removal of coal under surface mine highwalls, the technique is receiving wider acceptance underground.

Auger mining in the anthracite industry has been evaluated with an experimental continuous mining system. The capability of the auger to develop ventilating and supply connections between levels allowed the continuous mining machine to advance without delay. The auger has not yet been used in anthracite deep mines for the sole purpose of winning coal.

5.a Tunnel Boring Machines

The tunnel boring machine (mole) has been used in recent times as an effective means for cutting rock with compressive strengths to over 30,000 psi. These machines are normally designed to the specifications of the customer, and have been manufactured to develop tunnels with diameters from six feet to over 20 feet. In soft rocks the rate of advance is a primary advantage for its use (up to seven feet per hour in limestone). Normally, the tunnel walls are left in a condition which is sounder than can be obtained by blasting. Because of this, there is a corresponding reduction in roof support requirements. Personnel are not exposed to hazards associated with conventional tunneling methods.

The disadvantages to using a mole are primarily its high initial costs and lack of flexibility. If the tunnel to be cut is less than approximately 5,000 feet, it is conceivable that other means may be more economical. The mole's sole function is to cut tunnels within a specific range of materials. The maneuvering ability of a mole is limited, in fact one of its selling points is its capability to maintain alignment.

The tunnel boring machine has proven its effectiveness in cutting rock similar to the type found in the anthracite fields.[1] It can be

[1] Kenneth Cox, "Rock Tunneling with Moles", S.M.E. Mining Engineering Handbook, Section 10.4, pp.10-80.

used to place horizontal rock tunnels from the shaft to and across the veins, and for developing rock gangways below the coalbed or for a coal gangway in the coalbed.

The capital cost for a "mole" is expensive; a ten foot diameter machine will cost about $900,000 and a twelve foot system will be one million dollars.

The need for such a machine in coal mines is justified if the proposed tunnel workings are of sufficient length to offset the economics of conventional methods.

5.b Raise Borers

Raise boring is a method of developing large-diameter holes which are normally steeper than 30 degrees.

The machine normally works from the surface or at an upper level in the mine and drills a small diameter pilot hole to a lower level. Once the pilot hole is completed, a large (up to 20 feet) diameter reaming head is attached. By using the pilot hole as a guide, the reaming head cuts back towards the machine. The extracted material falls by gravity and is loaded at the lower entry.

Raise drills have been designed to provide travelways and connections for ventilation, material removal and service systems. They have been used for mining, and several systems for extracting coal are under development.

There is a U. S. Bureau of Mines study (S0122047) in progress to evaluate raise drills with diameters up to 20 feet, as well as augers, for mining coal to depths of 300 feet.

Raise drilling provides a rapid and safe means of developing shafts or slopes through hard rock and significantly reduces development costs resulting from conventional shaft sinking methods.

5.c Augers

Increasing use is being made of the drilling techniques of today's augers. Previously, they were used for drilling ventilation shafts and connections, and for some coal recovery at strip mines. They are now being evaluated as added tools for underground mining operations.

Through augering, the Wind Rock Coal and Coke Company in Oliver Springs, Tennessee, is mining previously unrecoverable underground seams. Management hopes to recover approximately 50 percent of these untouched reserves at the rate of 100 tons per three man shift.

Augering has the ability to economically recover coal in these hard-to-reach places, but much depends on the efficiency of the operating crews. Where access can be made, a reamer can be attached and the hole backreamed to 48 inches for supply connections. Augering can add considerably to recoverable resources. For these reasons, augering should definitely be evaluated as a part of the underground mining operation. However, there is a need for a smaller machine which would occupy less work space in anthracite headings.

5.d Borehole Drills

Boreholes have been used more frequently for ventilation than for other purposes. Now in-strata drilling machines are being used to drill large diameter holes into inclined seams of coal. These holes range in size from eleven inches to fifteen and three-quarter inches.

Hollow drill rods are used to carry compressed air to the drilling machine while providing the required thrust for advance. Because of the bell-shaped bit, the drill does not penetrate harder formations outside the coal seam, and therefore does not stray from the seam. Another important characteristic of this operation is that it moves forward as a single unit because the bit, drilling machine, and drill rod are directly connected to each other.

A twin version is also possible by having two drill bits in synchronization with air supplied by a single drill rod. The resulting cross-section would then be twice that of the single drill bit.

D.4.b Hydraulic Mining Systems

The development of new, highly-productive, mining systems is necessary for the revitalization of the industry. A fully integrated system of hydraulic mining (mining, transport, and hoisting) might help to answer the need.

1. Hydraulic Mining

A considerable amount of coal is being mined hydraulically throughout the world. One of the most successful installations is the Kaiser Resources Ltd. Mine in Western Canada. The steeply pitching bituminous seams are being mined by a technique licensed by the Mitsui Mining Company Ltd., of Japan. The Russian mining institutes have also reportedly performed much of the early research into this technique.

Mr. Robert L. Marovelli, Chief, Division of Mining Research, U. S. Bureau of Mines, gave a presentation on hydraulic mining, particularly about the Gneisenau Mine in Germany, at the recent Scranton -

Anthracite Research Conference,[1] January 6 and 7, 1975. His remarks were based on observations by an American study group. They were informed that the Gneisenau mine was a trial mine for a newer hydraulic mine to be opened next year. Five foot thick bituminous coal is being mined on a pitch varying from 15± degrees to 70± degrees. Gangways rise at about five degrees, and are spaced at about 50 foot intervals. Both gangways and final mining are done hydraulically. Coal is flumed along the gangways and then down the center slope where it is pumped horizontally about 4,300 feet to a shaft pumping station, and then vertically using a two stage centrifugal pump and clear water. It is reported that a productive rate of 1,000 tons per day is necessary for the system to be economically feasible. The highest daily production rate was 800 tons per day in this test mine. The preparation plant was the bottleneck in the system because it was unable to accept the quantities of water produced. Roof support was timber.

Hydraulic mining has been practiced in the United States for over 120 years, but only since 1958 has research been done on the mining of Pennsylvania anthracite using this technique.

In an early investigation, discussed previously in this Chapter, pressures were in the 2,000 to 5,000 psi range for an actual anthracite mine test. Within this range, though, the rather large diameter nozzles were causing relatively high flow rates. This resulted in an accumulation of water and debris at the coal face, while the production rate was not any better than conventional mining methods.

This and other investigations indicated that, at higher pressures and lower flow rates, the production rate could be increased while the water problem was reduced. More important was the fact that the efficiency climbs as the machine is operated at higher velocities.

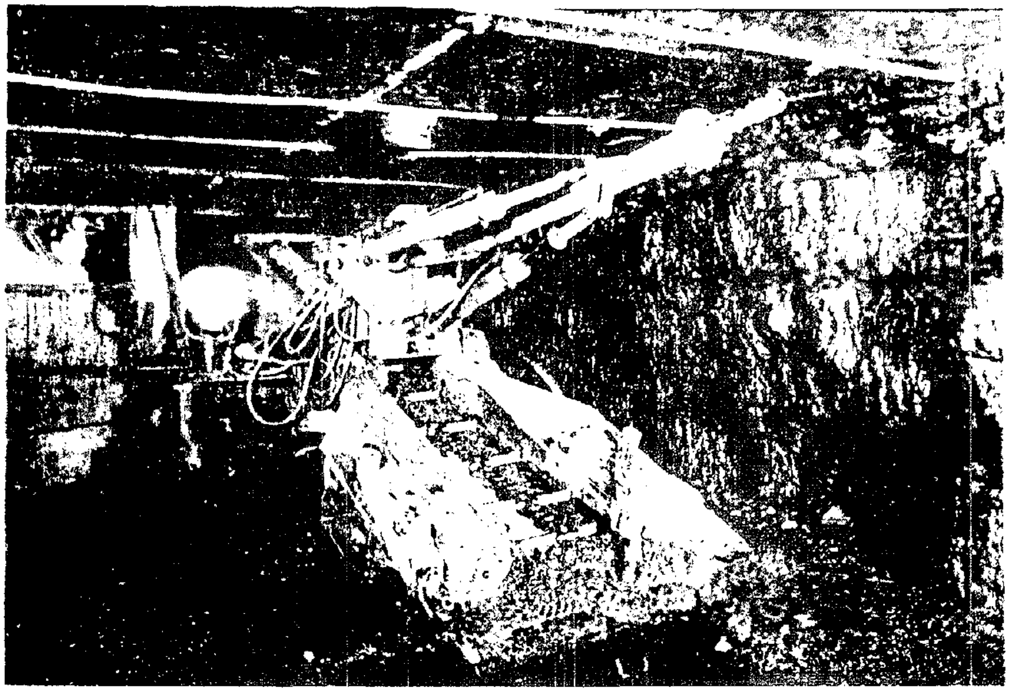
Advantages of high pressure hydraulic mining are:

- Reduced dust problem
- Low maintenance
- Potential operating efficiencies
- No blasting needed
- Coal can be broken into coarser sizes
- Spark-producing bits avoided
- Shape and size of entry can be controlled

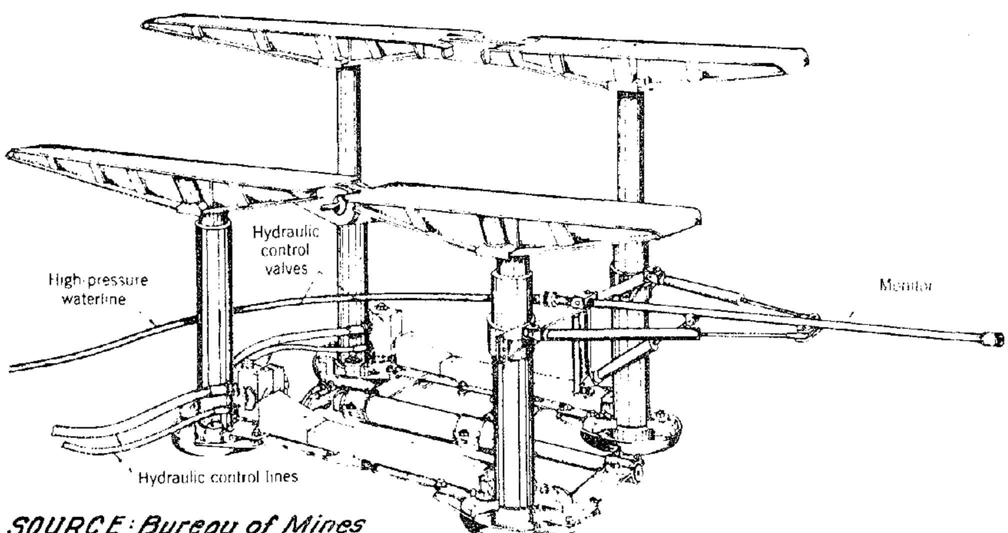
---

[1] Paper entitled "Research and Development for Deep Anthracite Mining".

HYDRAULIC MINING



Monitor Mounted on Conventional Loading Machine.



SOURCE: Bureau of Mines
Report of Investigations 6685 & 7090

Hydraulic Mining Machine.

PLATE V - 21

One of the biggest problems with hydraulic mining, or with any type of mining on steep pitches, is roof control. Time-consuming wood timbering methods are too costly. A method must be developed to support the roof, at least temporarily, and then extract the coal on retreat. Perhaps some variation of marching chocks discussed later in this Chapter may be adapted to hydraulic mining.

Another problem is the effect of the acid water on the equipment. Clear water could be used, but it is much more desirable to use the water already in the mine. Research is necessary on the use of noncorrosive material.

Progress in hydraulic mining is going ahead at a rapid rate in this country and overseas. Developments underway for 60,000 psi pumps and monitors may be applicable to the harder anthracite coal. Additives in the water may assist in agglomerating the water jet to reduce loss of kinetic energy at the face. Where larger sizes of coal are not important, emphasis can be placed on "smashing" the coal, rather than "cutting", resulting in the coal and water running from the face on steep pitches.

2. Hydraulic Transport

Especially when coordinated with hydraulic mining, there is a probable economic advantage of hydraulic transport of coal as compared with mechanical transport systems. This can include piping or fluming with either continuous or hydraulic mining. Piping could be either rigid or, preferably, flexible.

A hydraulic transportation system is now being developed at the Robinson Run Mine, in West Virginia, by the Consolidation Coal Company. In this particular system, water is mixed with the crushed coal near the mine face. The resulting slurry is pumped through an extensible hose and pipeline system to the surface.

Coal is usually flumed or piped to the slope or shaft bottom, where crushing reduces the coarse sizes to a slurry for efficient pumping by a slurry pump, or else it is injected into a previously pressurized water line. The hydraulic transport of the coal vertically to the surface is accomplished through slurry hoisting.

A Japanese company represented by Hitachi America Ltd., New York, New York, has introduced a machine called a horizontal "Hydrohoist" which can handle solids of any size that can pass through the feed and transport pipes.[1]

Not only is economics a big consideration, but a system of hydraulic transport is much safer than its conventional counterpart. Second only to roof falls as a killer, mechanical haulage is a very "unsafe" way to transport coal from the mine face. Other advantages of the hydraulic transport system are the reduction of coal dust, low power requirement, and a relatively maintenance-free life. The only major disadvantages are the degradation of the coal (at least with bituminous coal), which can affect its marketability, and the problem of dewatering at the breaker.

D.4.c. Roof Supports

The most important part of the mining system is the roof support and control of the surrounding strata. Underground roof supports, especially those in the advancing coal faces, have traditionally been some method of timbering (Plates V-22 to V-25). Other methods have been used briefly without any degree of success. Yielding steel props were employed to supplement timber cribbing during a longwall mining evaluation, but proved to be inadequate. Hydraulic chocks were planned in conjunction with a continuous miner test that was terminated before they could be utilized. Roof bolt usage is discouraged by present State policy. One of the newest roof control methods, the roof truss assembly, has never been used in anthracite coal.

1. Self-Advancing Hydraulic Roof Support

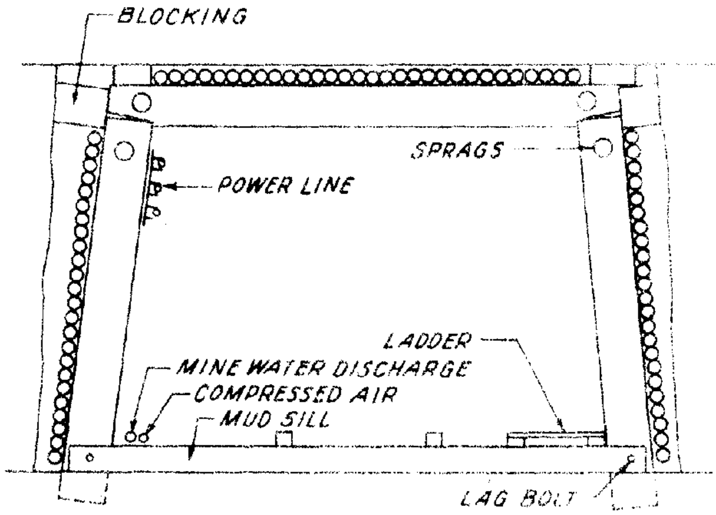
This system has been developed by a variety of manufacturers and is imported from European suppliers. Currently, there are "marching chocks" which will support up to 1,000 tons and have from four to six legs. Normally these chocks are employed in the longwall or shortwall systems at bituminous operations. In this country, they are seldom used on slopes that exceed ten degrees. Because of the nature of these mining methods, the supports are designed to advance in one direction only.

For a marching chock to be used successfully in anthracite coal on pitches up to 45 degrees (or more), there is a need to develop a support that will be capable of moving in two directions: first, to move along the working face as is the practice currently and, second, to be capable of moving up a steep pitch without tipping or experiencing

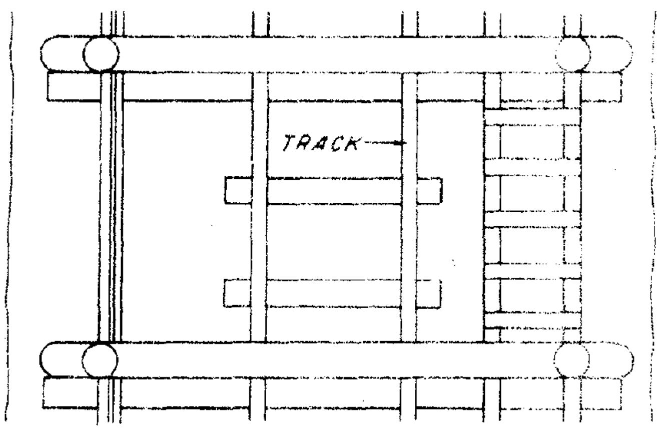
---

[1]"Hydraulic Coal Hoisting --- In Principle and Practice", Coal Age, November, 1973.

STANDARD TIMBERING PLAN
THREE PIECE SET
(GANGWAY, TUNNEL OR SLOPE)



LONG SECTION



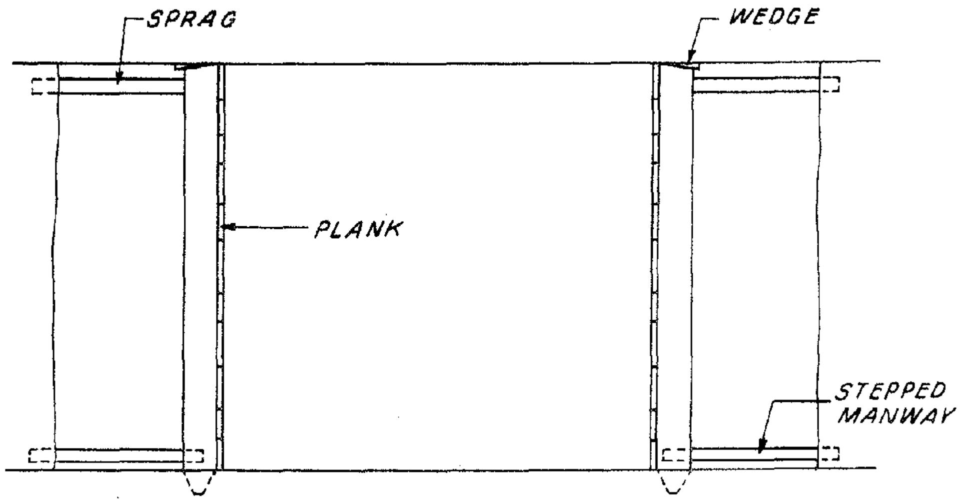
PLAN

SOURCE: A.B. RIEDEL, P.E.

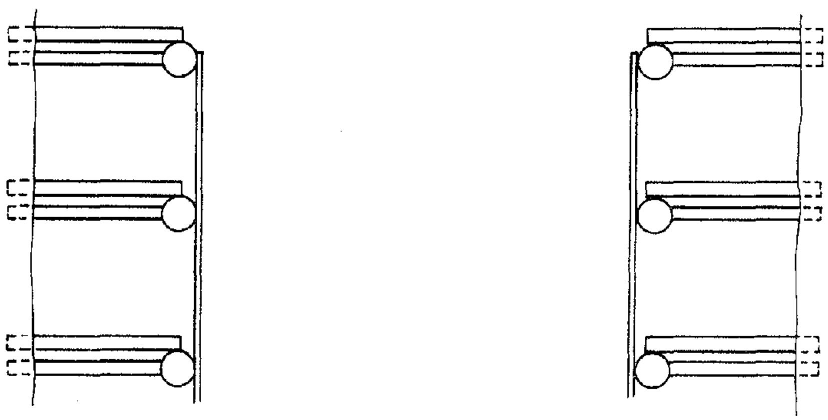
PLATE V - 22

STANDARD TIMBERING PLAN

TIMBER CHUTE
(COAL BREAST)



LONG SECTION



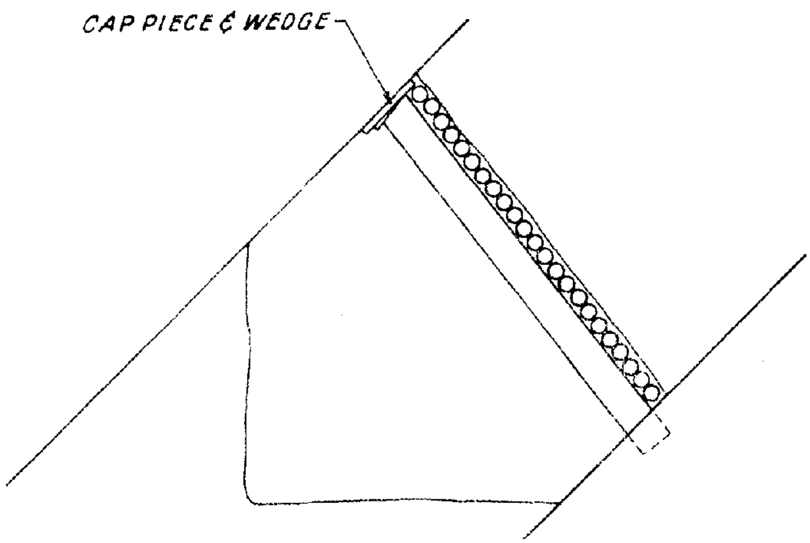
PLAN

SOURCE: A. B. RIEDEL, P. E.

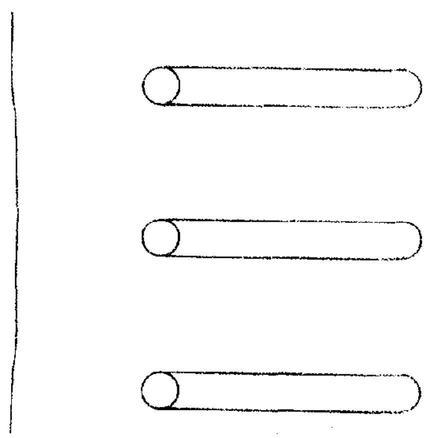
PLATE V - 23

STANDARD TIMBERING PLAN

ONE PIECE SET
(GANGWAY & HEADING)



CROSS SECTION



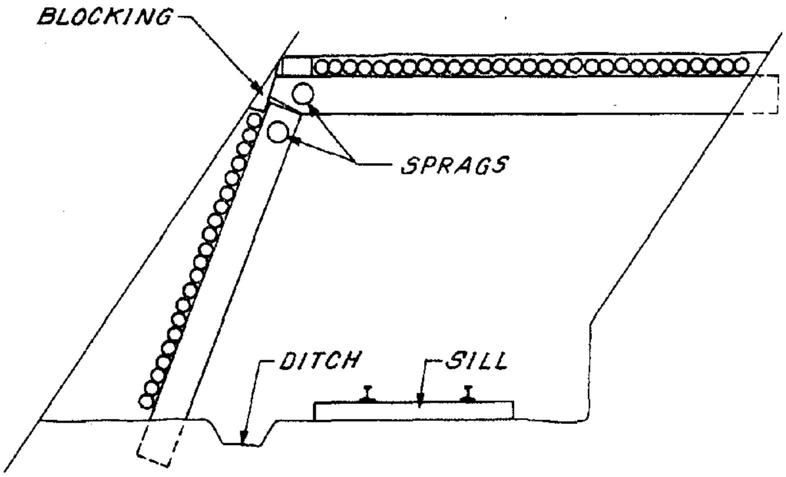
PLAN

SOURCE: A.B. RIEDEL, P.E.

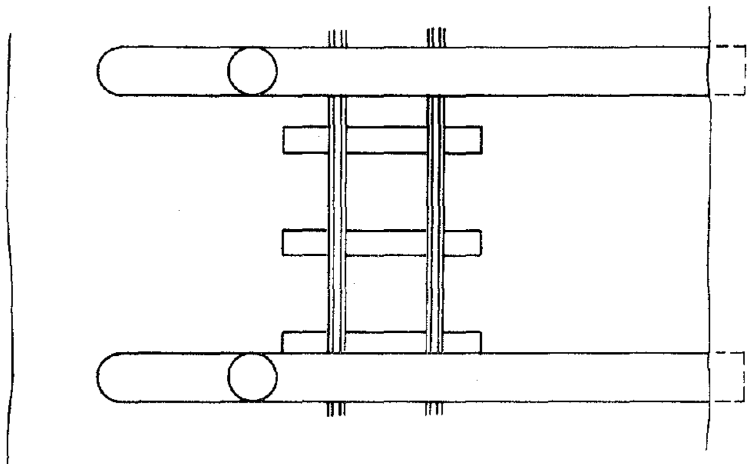
PLATE V - 24

STANDARD TIMBERING PLAN

TWO PIECE SET
(GANGWAY & HEADING)



CROSS SECTION

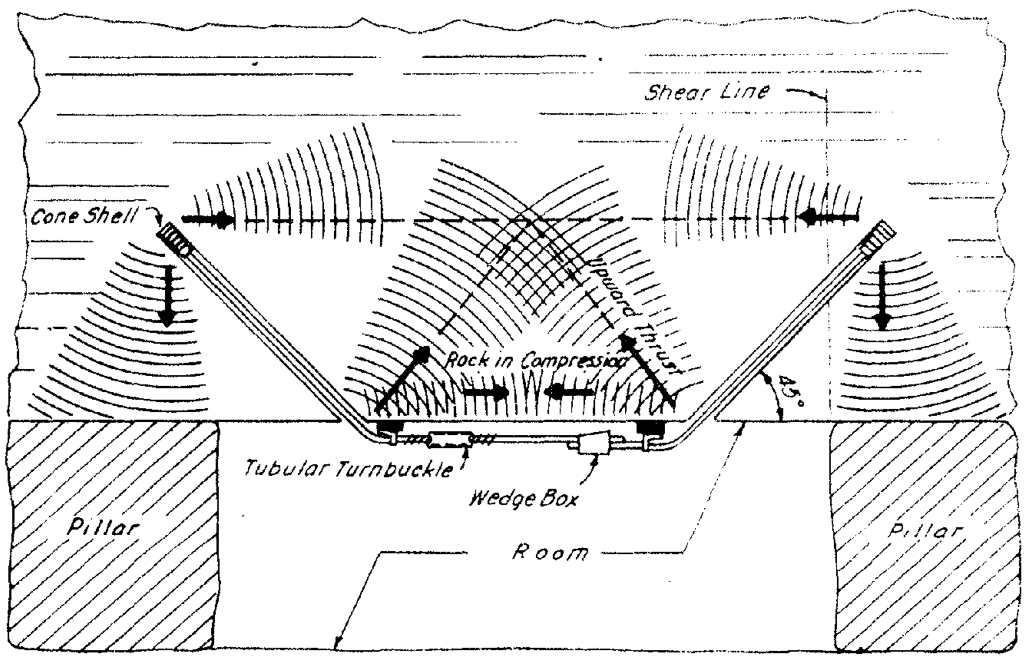


PLAN

SOURCE: A. B. RIEDEL, P. E.

PLATE V - 25

ROOF TRUSS



NOTE: Tension in the Steel Rods produces Compression in all Shaded Areas.

SOURCE: "Coal Age Mining Guidebook"

PLATE V - 26

hydraulic failure. Each leg in the chock should be capable of responding to changes in the roof height independently. One suggestion has been to further develop the six-leg heavy duty roof supports currently on the market to provide for lateral as well as forward movement. The up-slope chock would be capable of moving to the side and positioning itself while the two remaining chocks act as both a roof support and anchor. A self-advancing, self-positioning system of such a nature would permit the development of an efficient and safe shortwall/longwall mining method for pitching veins of medium thickness.

There is a self-advancing roof support system on the market which has not been used to date in this country and which utilizes a "six-leg triple-frame support". This form of marching chock could conceivably meet the requirements for steep pitch longwall mining or could serve as the basic system needed for further development. The marching chock also appears to be an ideal base for monitors in hydraulic mining.

2. Roof Bolts

It has been determined that the use of roof bolts in a situation where weaker roof members can be tied together will form a beam which is stronger than the sum of each individual strata acting separately.[1] Progress in developing roof bolt designs for anthracite have been curtailed by the Pennsylvania Anthracite Coal Mine Act and it is a constraint to any progress in this field.

The use of resin to reinforce bolt anchorage is a recent development that has dramatically improved roof bolt loadings in the weaker shales and coal strata. The resin, which cures in as little as 20 minutes, has held test loads two to three times the load of conventional anchorages with negligible bolt movement. There have been no tests in anthracite coal using resin bonds.

Another method for roof control is the roof truss assembly (Plate V-26). The system uses high-strength steel rods driven at angles into the roof which are then anchored with expansion shells at a predetermined depth over the pillar. The rods are then connected to each other, using turnbuckles, and are stressed under tension. The resulting effect is to put the exposed rock into compression to counteract the formation of the pressure arch.

---

[1]Lawrence Adler, Ground Control in Bedded Formations, Research Division, Virginia Polytechnic Institute, Bulletin 78, December, 1968.

The roof truss has been used in Pennsylvania bituminous mines with excellent results. In anthracite mining, it is felt that this form of roof support has great promise in areas where the roof condition is poor and the open spaces are required to remain exposed for extended periods of time.

It should be noted that if roof bolting is used in the anthracite deep mines, problems with the maneuverability of the bolting equipment can be expected. This will be especially true in areas of pitching veins where the working spaces will be very narrow. A "single-purpose" machine, unless compact, will tend to complicate an already congested area. Miner-bolting machines developed for bituminous coal have been tested successfully in a West Virginia Mine. Several miner-bolter systems are under Bureau of Mines contract for further development.[1] None of these systems under study are apparently designed to install roof bolting devices on equipment suitable for steep pitch mining. In order to reduce the number of required mechanical mining systems at the face, it would be desirable to develop either a shearer loader, roadheader, or similar device which will tunnel rock, extract coal, install roof supports, and perform retreat mining under pitching seam conditions.

D.4.d Summary

There is a wide choice of systems and components that have a reasonable potential for being practical and economical in anthracite deep mining. The next section presents a program.

E. EVALUATION OF RESEARCH AND DEVELOPMENT REQUIREMENTS

This Chapter has discussed all three methods of mining new coal, and has indicated that all of them are, within limitations, feasible to meet the demands of the future.

In Chapter III, predictions were made of the possible growth in anthracite demand through 1990, with consumption remaining constant for the years 1991-2010. Table V-1 shows how this growth may be expected to develop. The totals through 1990 are compatible with those shown on Plate III-2. This projection assumes that the combined production from culm, refuse and dredge will stay almost constant until the 1990's, when good quality supplies of these materials will become short. Deep mining can be expected to expand, but not for a few years because of the constraints discussed. The balance of the demand must, therefore, be met by surface mining.

---

[1] Mining Research Contract Review, U. S. Bureau of Mines, Vol.V, No.9, September, 1974.

TABLE V-1

PROJECTED PRODUCTION

1975 - 2010
Millions of Tons

	1975	6	7	8	9	1980	1	2	3	4	5	6	7	8	9	1990
Deep	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4
Strip	3	4	4	4	4	5	5	5	6	7	7	8	8	9	10	11
Culm, Refuse and Dredge	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2
Total	6	7	7	8	8	9	10	10	11	12	13	14	14	15	16	17

Subtotals:

	Totals 1975-90	1990-2000 Average Per Year	1990-2000 Total	2000-2010 Average Per Year	2000-2010 Total	1975/2010
Deep	34	5	50	6	60	144
Strip	100	10	100	10	100	300
Culm, Refuse and Dredge	43	2	20	1	10	73
Total	177	17	170	17	170	517

Source: Consultant's projections, as explained in text.

Even in these projections, it is realized that the development of surface mining - conventional or deep pit - can be seriously hindered by the nontechnical sociological, ecological and legal constraints, in which case deep mining may have to meet more of the demand at earlier dates than those shown.

In any event, a viable anthracite deep mine industry is necessary and desirable in the future. Therefore, steps must be taken to avoid its complete demise - with the corresponding lack of skills - such as happened to the Virginia anthracite deep mining.

The existing industrial base, small as it presently exists, is a necessary one on which to build. A start on revitalization must be made now. The following technological improvements and innovations will substantially contribute to this revitalization.

E.1 Surface Mining Recommendations

The recommendations for conventional and deep pit surface mining have been combined because generally they can apply to both types of surface mining.

Subject to the verification of feasibility by others, notably the Pennsylvania State University study, it is recommended that, through the State and/or Federal Geological Surveys, a program be initiated for drilling at depth to prove out coal veins in selected areas. The purpose of such drilling would be to acquire information needed to prove the economic and technical viability of this recovery method. This information would include not only the thickness and quality of coal at various depths, but the type and characteristics of overburdens.

It has been brought out that the significant revitalization of Pennsylvania anthracite lies with the utilities. The benefits of this deep drilling exploration then might be the difference as to whether or not the utilities eventually burn mined anthracite coal in quantity.

It is recommended that greater effort be placed on rock mechanics for stability (and safety) of pit walls and to confine the extent of overburden removal. This should include newer techniques of rock pinning and other stabilizing developments. These techniques should be demonstrated as part of the deep pit mining system.

Developments in improved rock fragmentation would assist in faster material handling. Even with present equipment considerable unproductive time is involved in handling oversized rock. It is estimated that with the smaller draglines frequently used, say eight cubic yard capacity, this loss of productive time can amount to as much as $75,000 per year for one machine and operator. This does not include the proportional share of profit from coal which could have been won during unproductive periods.

The Commonwealth of Pennsylvania has carried out some backfilling of anthracite strip pits for acid mine drainage (AMD) abatement. Where possible, future efforts should also have the additional objective (consistent with the Pennsylvania Law) and be guided by the need to backfill abandoned strip pits above active or potentially active deep mines. This AMD reduction would serve two current areas of emphasis - energy production and pollution abatement.

Developments in economical protection for trailing cables from electrified strip mining equipment (from standpoint of safety) would assist the strip mining industry.

Sandstone and conglomerate overburdens prevail throughout the Anthracite Region, but are especially dense in the Southern and Western Middle Fields. These overburdens are much harder than the mostly shale overburden encountered in bituminous strip mining.

E.2 Deep Mining Recommendations

The postwar mechanization tests in the region, as discussed, were helpful in defining the limitations of the various approaches to mechanization. The time required for the tests and readapting the equipment when necessary indicate that perhaps five to ten years will be required to develop a productive anthracite deep mining system.

Past tests have shown that any system is only as good as its weakest link - this includes mine development, winning the coal, roof support, and haulage. A breakdown or slowdown in one element can result in the entire system being unproductive. All components, as well as the complete system, then tend to be denigrated.

Recognizing the inability of today's anthracite deep mine industry to underwrite a meaningful research and development program, governmental assistance in this direction is essential. The unique demands for a mechanical extraction-loading-transportation method require a broader look at worldwide systems operating on steep pitches. If the domestic anthracite mining industry is expected to contribute to the nation's future energy needs within a reasonable time frame, existing technology must be adopted or adapted.

Based on our literature search of domestic and foreign development, as a first step, it is recommended that a task force of competent design-mining engineers from industry and government, intimately familiar with anthracite extraction problems, be appointed to personally evaluate and report on systems in use in the United States and overseas. Based on the findings of this group, either adoption of promising components, or new design concepts should be considered.

It is recommended that these machines be demonstrated to the industry and to the potential investor. Since productivity per man-day is less than one-half that of mechanized bituminous mines there is an ample incentive for such a demonstration. This should follow the usual procedure adopted by the Bureau of Mines, that is, a joint industry/Bureau effort. Equipment would be demonstrated in conjunction with operating systems.

A suitable working mine, preferably in the Minersville Synclinorium (see Chapter IV), should be offered by an operator from the industry in which to demonstrate the most potentially productive equipment. This mine should be one of the larger operating deep mines, and capable of expansion to at least 150,000 tpy (see sample cost calculation for a deep mine of this size which follows). Miners should be supplied by the industry and the maintenance of equipment be performed by the operator. The existing deep mine industry has reached the point where large companies with capital no longer exist - the largest deep mine having an annual production of only 90,000 tons per year. Besides research and development, except for smaller pieces of machinery, governmental funds would be needed to purchase the larger equipment for the demonstration mine. This investment, if successful, would:

1. Tend to retard the decline of the deep mine industry.

2. Benefit the nation over the long term as it turns to coal for solutions to its energy needs.

3. Encourage and demonstrate to larger well capitalized domestic and foreign firms (generally not now in the industry) that a modern, well engineered and equipped anthracite deep mine can be productive and economic. These might include large companies in the bituminous field, large ferrous, titanium, or zinc processing firms, or foreign firms.

4. Encourage the tapping of the deeper coal, where the major reserves are located.

5. Change the image of the anthracite miner to that of a machine operator or technician, thus making it easier to attract and hold skilled manpower.

6. By designing the mine to comply with current standards, provide a basis for improving deep mine safety.

7. Provide an additional stabilizing influence on the area economy.

Analyzing past research efforts and equipment applicability, it is reasonable to consider a systems approach to anthracite mechanization. Conventional methods, whether for development, coal winning or transportation, can no longer be expected to provide the production required for future energy needs. Attracting manpower, investment and markets demands a successfully demonstrated system that will eliminate the hazardous environment, while producing substantial increases of fossil fuel over the long term. Only through the adoption or adaptation of the most promising components can these goals be realized.

Equipment availability, as discussed previously, is confined to existing domestic and foreign components. Recent evaluations have not been made to determine a 'best-fit' relationship for a complete system. Therefore, the following recommendations are made.

E.2.a. Recommendations for a Mechanical Continuous Mining System

A mechanical system is being given priority over a hydraulic system because the basic equipment is mostly "off the shelf", whereas the hydraulic systems are still undergoing considerable development.

It is recommended that a combination of the following equipment should be tested and evaluated for individual performance and as part of a system.

Preferred Combination of Mechanical Equipment

1. Development:
   - Road Header (coal gangways and rock tunnels in conjunction with a roof bolter).
   - Raise Borer(ventilation connections in coal).
     Raise Borer (shafts and airways)

2. Coal Winning (short wall):
   - Shearer Loader Combine

3. Roof Support:
   - Self-advancing bi-directional hydraulic chocks.

4. Transportation:
   - Monorail

The roadheader was recommended over the impact ripper because it is understood to have a higher rate of production. The roadheader is also a versatile machine which can cut the various gangway sections imposed by most pitches. The impact ripper is a relatively new machine while many roadheader machines have demonstrated their capabilities throughout the world. (It is reported that roadheaders are being used in development of over 80 percent of all mechanized headings in the U.S.S.R.).

Raise borers have advantages over augers for cutting ventilation connections primarily due to the use of rolling cutters instead of drag cutters. No raise borers are accepted as permissible by the Bureau of Mines but others have stated that the modifications to make them permissible would not be great. While some augers are permissible, they have not been developed for confined underground operation. Also there is an advantage in using one piece of equipment rather than two (auger and raise borer), therefore a raise borer is recommended.

The shearer loader combine along with self-advancing hydraulic chocks appear to be the most promising combination for continuous mining in steep pitches.

For transportation, the monorail apparently was successfully tested in the St. Clair test. More cars should be used to increase the efficiency. However, it still has the traditional transportation problem in steep pitches of "last car in - first car out". Hopefully a method could be developed to return cars while other are unloading.

Hydraulic fluming has promise as a cheap efficient means of haulage. However, it would appear that there are problems to be overcome at the shaft bottom with water handling, unless it can be coupled in a unified system with hydraulic hoisting.

Hydraulic monitors should also be tested for their effect on dust control.

The Task Force might find, or experience might show, that one or more of the above components were unsatisfactory even after modifications. Priority choices for other equipment are noted as follows by number. It will be seen that some items appear under more than one heading due to their applicability in other areas:

Alternative Mechanical Equipment

In the event that one or more of the components in the preferred system prove less than satisfactory, the following equipment should be substituted, where appropriate, in the order of preference listed.

Development:
1. Impact Ripper (rock and coal)
2. Augers (ventilation connections)
3. Tunnel Boring Machine (rock tunnels)

Coal Winning
1. Impact Ripper
2. Raise Borer
3. Borehole Drills (thin seams)
4. Continuous Arc Miner (thin seams)
5. Augers (thin seams)

Roof Supports:
1. Roof Trusses

Transportation;
1. Hydraulic Fluming
2. Hydraulic Piping and Hoisting (rigid or flexible)

Longwall systems are not being recommended for study as they are not considered practical in the geologic conditions of the anthracite fields.

It is not considered necessary further to evaluate conventional conveyors and mine trains at this time, but this does not preclude their use in conjunction with other elements being tested. However, there is a need for development of an extensible articulated conveyor belt, useful in both anthracite and bituminous mines.[1]

Sample Cost Evaluation for Mechanical Continuous Mining System

The following cost evaluation is to test the possible benefits that might occur by installing a modern mining system ("Preferred Combination") in an existing mine such as the demonstration mine. To determine the economic feasibility of such a mine it is proposed to postulate a coal vein seven feet thick, with small percentages of pyrite material, that is pitching 45 degrees.

The advance mining system is to consist of two roadheader type continuous miners to develop gangways within the vein. Two roof bolting systems and a 24 inch diameter raise borer (for ventilation) will be used in support.

The retreat mining is to be accomplished using a drum shearer loader in conjunction with self-advancing, bi-directional hydraulic roof supports. Mining is estimated at ten feet per shift, based on, say, 100 feet between gangways.

The transport system will be developed around a monorail having independently controlled mine cars.

Such a mechanical mining operation should extract 675 tons per shift and utilize 25 men. With a 225 day production year the mine might yield approxiamtely 152,000 tons.

Development costs are estimated to be $7.50 per ton of coal mined.[2]

---

[1] CMU/NSF - RANN Workshop on Advanced Coal Technology, October, 1973, p.III-28.

[2] S. P. Wimpfen, "Mine Costs and Control", SME Mining Engineering Handbook, 1973, p.31.

Capital costs for production are estimated as:

Advance Mining		
2 Roadheader-type miners (250 HP)	$500,000	
2 Roof bolting systems	150,000	
1 24 inch diameter raise borer (ventilation)	75,000	
		$ 725,000
Retreat Mining		
1 Drum shearer loader (150 HP)	$275,000	
12 Self-advancing hydraulic roof supports (100 ton)	600,000	
		$ 875,000
Transportation		
1 Monorail (5000 feet with 30 cars, 150 HP)		$ 250,000
Total Capital Costs		$1,850,000
Ten Year amortized at 8%, per annum		275,500

Annual Operating Costs (225 days at one shift per day)

Labor Costs (25 men x $90/day x 225 days)	$506,250	
Overhead Cost ($1,800/day x 225)	405,000	
Miscellaneous Operating Costs, Ventilating, pumping, material, etc. ($1,500/day x 225)	337,500	
Total Annual Operating Costs		$1,248,750

Expenses Incurred to Mine 152,000 Tons

Development Costs ($7.50 x 152,000)	$1,140,000	
Amortized Capital Costs	275,700	
Operating Costs	1,248,750	
Annual Mining Costs		$2,664,450

With the varying average sales value of coal, the returns to be anticipated from this operation are as follows:

Average Sales Value Per Ton (ROM)	Gross Revenues	Gross Costs	Net Income
$15	$2,280,000	$2,664,000	$ - 384,000
18	2,736,000	2,664,000	72,000
20	3,040,000	2,664,000	376,000
25	3,800,000	2,664,000	1,136,000
30	4,560,000	2,664,000	1,896,000

The conclusion to be drawn is that such a mine will break even at a run-of-mine price of $18 a ton. If, therefore, the price of prepared coal stays above about $30 a ton - a good possibility, given the current state of affairs - the mine should return a reasonable profit.

It is necessary to demonstrate that such a system will work in the Anthracite Region and will produce at or above the rates assumed. A testing of such a system is well justified.

The above example illustrated the feasibility of a moderately small mechanized continuous mining system. Production from this system is not inordinately out-of-scale with existing anthracite deep mine operations. It is felt, however, that economies of scale would result from a more extensive mechanized system capable of significantly larger rates of production.

E.2.b Recommendations for a Hydraulic Mining System

Recommendations for a hydraulic system cannot be as definitive as those for a mechanical system, as equipment is not as standardized and much of it is still under development. Within these parameters, it is recommended that the following be tested and evaluated.

Development and Coal Winning

1. Equipment with high pressure nozzles (up to 60,000 psi). The optimum pressure/volume should be determined.

2. Use of materials that will not be corroded by acid water.

Roof Control

Same priorities as for the mechanical system.

Transportation

1. Fluming

2. Piping

3. Hydraulic hoisting to surface.

Preparation

Study methods of handling excess water at surface.

Cost Calculation

The state-of-the-art in hydraulic mining is changing rapidly. These changes drastically alter cutting rates, recovery rates, etc. and, therefore, similar calculations as carried out for a mechanical system would be highly tenuous. Further research of the hydraulic system would establish reasonable production levels from which costs could be determined, therefore, no attempt has been made to parallel the earlier calculations.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The previous chapters describe the various facets of the anthracite industry, both from an historical and present day point of view. The problems besetting the industry and the potentials for revitalization can be summarized as follows.

A.1 Constraints

Anthracite comprises approximately one percent of the total coal reserves in the U.S.A.

The anthracite coal veins are, for the most part, steeply pitched and overburdened with hard rock, thus differing considerably from the flat beds of most of the bituminous coal in the U.S.A.

With the great improvements made over the years in earth-moving equipment, strip mining has become the most attractive way of winning new coal.

The methods of coal extraction in deep mines are still very much the same as 100 years ago. Several items of newer equipment have been tested in anthracite mines, but have, generally, either been unsuitable or have not been adopted for a variety of reasons, not the least of which is economic. In short, no one in the United States has yet adapted or developed a good system for deep mining anthracite.

The few utility companies that burn anthracite prefer the fine coal. For this and for economic reasons, they are using culm banks almost exclusively. Environmentally, this is beneficial to the region in that it helps to remove these eyesores and restore the land. However, such use of waste material does militate against the development of new coal.

Fragmented ownership, especially where the surface and mineral rights have different owners, is a constraint on assembling large tracts for economical working.

Most of the deep mines in the anthracite fields are flooded. Substantial pumping costs would be incurred to drain and operate these mines. This acid water would need treatment before discharge into watercourses; this could be considered a constraint, but the law applies equally to other industries and so cannot be regarded as discriminatory.

Historically, anthracite has been prepared and marketed in ten size gradations. Each size means a separate step in the preparation process. Perhaps more important, each size means a separate storage space for washed coal. Not only does this take up a lot of space, but not all sizes sell at the same rate, and frequently slow-selling sizes have to be sold at cut rates. An analysis of present and potential markets indicates that such a proliferation of sizes is not necessary.

The high cost of anthracite, compared with bituminous coal and - until recently, at any rate - with other forms of energy, has been the main reason for the near-demise of the industry. From 1972 Bureau of Census material, an average industry value of net sales and receipts of $13.32 per ton was established. Bituminous coal was correspondingly $7.94 per ton. Coking coal, on the other hand, averaged $16.25 per ton. (Prices later than 1972, for all types of coal, have been heavily distorted due to the energy crisis, and it is not felt that comparisons among the various types are reliable). Even with the possibilities inherent in a changed energy picture, anthracite is not attractive to many users because its production is so low. In fact, production is substantially below the demand of even today's reduced markets.

The lack of cost data posed serious problems for the Consultant in analyzing the competitive position of the anthracite industry. The operators were either unable or unwilling to provide cost information, and published data is insufficient for a good analysis.

With the decline of the industry, there has been a corresponding lack of interest in producing equipment to burn anthracite. Generally, manufacturers have done nothing to upgrade their anthracite firing techniques for many years. Much the same can be said about home-heating furnaces - improvements are virtually non existent and many firms have gone out of business. One estimate is that the boilers for a large power plant would cost from two to two and a half times their bituminous counterparts.

Most of the production of anthracite is in the hands of a few of the bigger companies. Generally - but not universally - the productivity, measured in tons per man day, increases with the size of the organization, indicating a marked economy of scale.

With the decline of the industry from 50 million tons a year a quarter century ago to barely six million tons annually today, there has been a corresponding loss of skilled, and unskilled, labor. Most of the experienced miners who are still alive are too old to return to the mines, and the image of the industry is low, even in the region. Prior to the current (January 1975) recession, labor shortages had caused some deep mines to close and prevented others opening. At present, the situation is stabilized due to the return to the coalfields of workers rendered unemployed elsewhere. Any revitalization will require training of new workers.

Five of the six railroads serving the Anthracite Region are bankrupt (the Delaware & Hudson Railroad being the exception). The decline in mining has contributed substantially to this situation. There is considerable concern that the railroad reorganizations now being considered by the U. S. Department of Transportation and the U. S. Railway Association will result in the abandonment of a substantial mileage of trackage and, worse yet, rights-of-way.

The Mine Enforcement and Safety Administration was established under the Federal Coal Mine Health and Safety Act, 1969. Certain requirements of this Act - especially those relating to ventilation, safety catches, automatic couplers and hoisting problems - have been very difficult to comply with in the anthracite fields, and MESA officials have issued waivers in some situations on a mine by mine basis.

The Pennsylvania Anthracite Coal Mine Act of 1965 has one requirement that proves cumbersome in operation; that is, that an operator desiring to use roof bolts has to have the approval of three mining inspectors and written permission from the Commissioner of Deep Mine Safety.

The Pennsylvania Surface Mining Conservation and Reclamation Act, 1971 has one constraint that causes problems in anthracite country - the requirement that no slope shall exceed 35 degrees. Much of the bottom rock exceeds this pitch, and consequently would need to be blasted and flattened, a process that also requires removing more vegetation than otherwise.

A.2 Potentials

In opposition to the constraints just listed, there are several factors that would justify a healthy anthracite industry.

The total amount of anthracite still in the ground is estimated at 17 billion tons. This includes pillars etc. in existing and abandoned mines as well as virgin coal. There are ample reserves, even for a greatly revitalized industry, for several centuries.

The Anthracite Region is located within 150 miles of one-eighth of the population of the United States, thus making it geographically attractive to large potential markets.

Several industries are dependent upon anthracite, mostly as a raw material source of carbon rather than as a fuel. Some electric utility companies have indicated that they would not preclude anthracite as a source of fuel if the availability and price were right and the techniques of burning could be improved.

Anthracite has a low sulphur content, averaging slightly below the 0.7 percent limit to what can be burned without sulphur dioxide stack scrubbers. It has been estimated that these scrubbers can add from $50 to $100 per installed kilowatt (i.e. $40 million to $80 million on an 800 megawatt generating station), and can reduce the efficiency of the plant by as much as fifteen percent. Thus anthracite does have some attraction for users of coal, notably utility companies. There is some disadvantage in the low sulphur in that electrostatic precipitators do not work as efficiently in removing the fly ash as they would with a higher sulphur coal.

The current (January 1975) shortage of natural gas in northeast Pennsylvania has revived an interest in coal gasification, especially among those industries such as the Glen-Gery Corporation who depend on gas for their processes. Gasifiers presently on the market are essentially a 30 year old design, but several are quite functional and are available to prevent the shut-down of process industries and extensive unemployment.

During the past year Bethlehem Steel Company acquired the Greenwood Properties to become the first captive operator in the anthracite industry. Bethlehem's investment and the unconfirmed, but repeated, reports of financial interest in anthracite mining on the part of other domestic and foreign industrial consumers indicate that capital is available to the industry.

Taking these facts into account, and assuming some use of anthracite by the utility industry, a possible demand of 17 million tons per year in the 1990-2000 decade is predicted.

The Energy Supply and Environmental Coordination Act of 1974 prohibits, with certain reservations, any power plant (and permits the prohibition of other major fuel burning installations) from burning natural gas or petroleum products if such plant had the capability and equipment to burn coal at the date of the enactment of the Act. The apparent effect of this Act is to stop any possible conversion of coal burning plants to other fossil fuels, thus increasing the potential for the use of coal. More important, it may be a step towards a national energy policy to burn more coal.

The current (January 1975) price of oil results in an energy equivalent cost of about $2.00 per million BTU, thus can be equated with anthracite selling at approximately $51 a ton, a price well within the capabilities of the industry to meet.

> The possibilities for substantial revitalization of the anthracite industry lie with the utility companies. Programs and research and development should be directed towards this end.

B. RECOMMENDATIONS

B.1 Introduction

As has been noted throughout this report, events affecting the energy situation in the United States are occurring frequently. These events, for the most part, are opening up opportunities for the revitalization of the anthracite industry that should not be lost. These recommendations take this situation into account, hence most of them call for early action.

It has been shown in Chapter III that there is a potential market, by 1990, of at least 17 million tons a year of anthracite. It has also been shown that present production is just over six million tons a year.

There is, therefore, a potential increase of 11 million tons a year by 1990. Table V-I shows the projected production of anthracite by various mining methods.

An Action Plan has to be developed that will ensure that these markets are obtained and that the production will satisfy these markets. The Action Plan has to be feasible and attractive to the anthracite industry, to present and potential users, and to Local, State and Federal Governments.

Before presenting an Action Plan, there is one major aspect that has to be discussed. As noted elsewhere, there is considerable uncertainty as to the future of the anthracite industry. At present (January 1975) the price of coal is at or near an historic high, but what the future holds is a matter of deep concern.

A good part of the uncertainty stems from the lack of a National Energy Policy. This observation has been made by many persons during the gathering of data for the study, and the Consultant's own staff regard the matter of critical importance.

The basic question the industry is asking is how seriously are we to take "Project Independence"? Is the country expected to develop its natural energy resources in order to reduce or eliminate imports? And how big a role will coal play? Will it merely be a stopgap measure for, say, 25 years until the bulk of electricity generation is by nuclear plants, or will the demand for coal be indefinite?

In spite of this lack of an energy policy, there are some philosophies that can be expounded. In the present uncertain circumstances, even if imported oil were to become "cheap" in the near future, it seems unlikely that the electric utility companies would invest heavily in new oil-burning plants; surely they would select a fuel where supplies could be more certain. If this be so, then coal - meaning bituminous and anthracite - would be a desirable fuel for several decades.

For all power plants that burn coal, anthracite has the great advantage of not needing sulphur dioxide scrubbers. A relaxation of the present regulations is not beyond the bounds of possibility; however, with the national drive towards a better "quality of life", it would appear that such relaxation would be comparatively temporary, in which case anthracite would still be an attractive choice.

Should these uncertainties be resolved in such a manner as to encourage the production of anthracite, then the present reluctance to invest in the industry may be largely overcome.

B.2 Action Plan

This study shows that, without the substantial use of anthracite by the utilities industry, there is unlikely to be any appreciable growth in demand.

The action plan must be addressed to making anthracite attractive to the utilities, and others, by providing adequate long term supplies, by competitive pricing, and by improving the techniques of burning the coal.

It is anticipated that there will be a strong reaction on the part of the coal companies to investing in mine development on the scale of 17 million tons a year without assurances of markets. By the same token, very few potential users are going to make long term commitments to use anthracite until they have strong evidence of a much improved supply.

Therefore, confidence has to be established on both sides.

To achieve this confidence in the anthracite industry, it is necessary that a twofold action program be initiated that would

- stabilize the market by policy decision

- lower the cost of production and utilization by research and development

Both actions are, of course, complementary and interrelated.

Policy recommendations relate to governmental and private activities to stabilize the anthracite market. The initiation of these recommendations are intended to create an environment conducive to private and/or public research and development expenditures.

Research and development programs are designed to improve the competitive position of the anthracite industry relative to alternative energy fuels and industrial material resources. Successful research and development will enable the industry to achieve greater production at lower unit costs. Moreover, improvements in combustion technology and research on anthracite blends could result in lower consumer costs.

The Consultant strongly recommends that both the policy programs and research and development programs be given equal and full consideration, as it is unlikely that anthracite revitalization can, in fact, be accomplished without these mutual activities.

Plate VI-1 indicates the series of actions proposed.

POLICY RECOMMENDATIONS ("Stabilize the Market")

Recommendation 1 - National Energy Policy

As has been discussed earlier in this section, a long range National Energy Policy should be formulated and put into effect as soon as possible. This will provide direction to users, especially the electric utility companies, which, in turn, would indicate the potential markets that the anthracite industry could hope to capture.

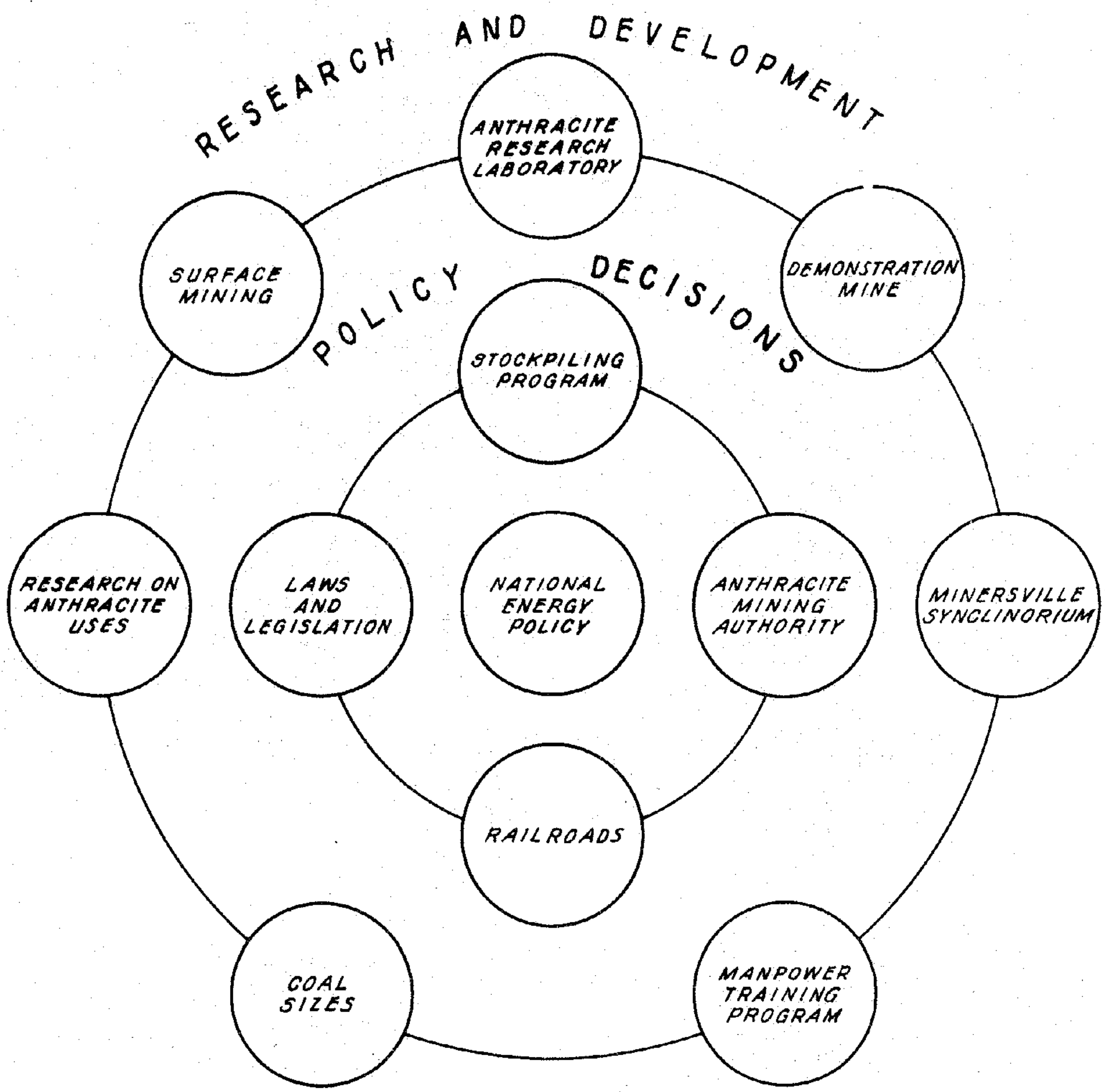
Recommendation 2 - Stockpiling Program

That the Federal and/or State Governments initiate a stockpiling program. Although it is felt that Government intervention in the industry should be kept to a minimum, this does appear to be one case where Government should act as a catalyst to start the revitalization process.

The stockpile would be designed essentially for run-of-mine coal to avoid unnecessary and costly reprocessing for future sales. A stockpile of run-of-mine coal would, in addition, reduce the storage requirements as compared to the separate storage spaces necessary for each of the various sizes of prepared coal.

It would, however, be necessary to stockpile some prepared coal, as sales from the stockpile would be prepared to the size specifications of the user and the remaining sizes of prepared coal would have to be stored for future sale. The storage space of prepared coals could be further reduced, as shown in Recommendation 11, by the preparation and marketing of anthracite coal into fewer sizes. The present ten size gradations do not appear to be warranted.

It would be desirable to situate the stockpile at or near a centrally located preparation plant. Since the anthracite operations are distributed over 480 square miles, in four fields, more than one site would be necessary. The maximum number of sites would be four - one for each of the four fields - although less than four sites may be practical.



ACTION PLAN

PLATE VI - 1

The stockpile would serve several purposes. First, it would ensure a "market" for excess coal. Secondly, the growth of a stockpile would be more of an incentive for, say, utility companies to commit to the use of anthracite than would other agreements. Third, by maintaining a guaranteed market at a price linked to some cost-of-living index or, even better, a yet-to-be-invented Cost of Energy Index (COEI), there would be a continuing incentive for producers to maintain long range production. Consumers would also be assured of supplies at reasonable prices. Fourth, it would eliminate the effects of the variations in seasonal demand, which, in the home heating market, are still pronounced. Fifth, the guarantee of a market would encourage capital investment in the industry.

The purchase price of coal for the stockpile should be set originally at not more than, say, 80 percent of the free market price. The stockpile would absorb surplus production, but there would still be a strong incentive for producers to sell on the open market. Should the COEI drop due, for example, to a reduction in oil prices, then the 'buy' price at the stockpile would also drop.

There is, therefore, no guaranteed minimum price for coal, and, if the price of energy did drop drastically, there could still be problems in the industry (it is hoped that a National Energy Policy will handle this eventuality). Alternatively, the Government may wish to set a minimum support price. The main purpose of the stockpile is to encourage development of new mines, ensuring that any initial overproduction can be absorbed until the corresponding new markets have been developed.

It is suggested that the Government would normally sell from the stockpile at a small profit, say ten percent over market prices, so that the cost of such an operation would not be a charge on the taxpayers and so that the stockpile would not compete directly with sales of current production.

Tieing the stockpile price to an energy index would establish that additions or reductions in the stockpile would reflect market conditions. A "pricing" mechanism of this nature would allay the producers' concern of possible government action that would arbitrarily effectuate price changes. In other words, the stockpile price would be "controlled" by changes in the demand-supply relationships in the energy market.

It is also suggested that a stockpile should be phased out when a revitalized industry is operating on a sound free market basis, and the need for it no longer exists.

It should be noted that a coal stockpile program has a precedent in the Government's price support and storage of grain that has been in operation for a number of years. It should not be compared with the several stockpiles of strategic materials, which were formed for national defense purposes and not for the stabilization of supply and demand.

- - - - - - - -

Low interest or no interest loans and/or long term contracts are possible alternatives to the stockpile program. With the uncertain state of the industry, funds at favorable interest rates are not available to the coal operators, who are only able to procure capital by paying a premium in excess of the prime interest rate. Government supported loans could provide fresh sources of investment capital for financing modernization. By reducing potential losses, operators would have some incentive to expand their production. However, government supported loans would not directly improve market stability and, consequently, the incentive to the operator would be muted.

Long term contracts would, alternatively, effectuate a stable market. If utilities, for example, are to use anthracite they would need a guaranteed supply of coal for the life of a generating plant, or approximately a thirty year supply.

Each alternative, or both in concert, require that either the operator and/or the consumer incur fairly substantial risks. The stockpile, on the other hand, is intended to create an environment that would encourage private investment and produce the incentive for eventual long term contracts. Therefore, government supported loans or long term contracts would not, at this time, be sufficient to substantially reduce the considerable uncertainty nor to establish the necessary mutual confidence.

Recommendation 3 - Anthracite Mining Authority

That a study be conducted to consider the creation of an Anthracite Mining Authority. The Authority's principal purpose would be to support anthracite revitalization through the implementation of this Action Plan and other recommendations. The study is intended to investigate the nature, structure, functions and feasibility of such an Authority. Suggested possibilities are:

Nature: To plan, promote and administer federal/state anthracite policy and plans.

Structure:

(a) Policy Board - consisting of representatives of producers, industrial and utility users, government, labor, education and other affected and interested parties. Representatives could be appointed by the President and the Governor of Pennsylvania, similar to the Appalachian Regional Commission.

(b) Staff for administration, planning and operations.

Functions:

(a) Administration of Stockpile Program.

(b) Administration of Anthracite Research Laboratory.

(c) Administration of Anthracite Demonstration Mine.

(d) Encouraging and coordinating the efficient development and uses of anthracite resources.

(e) Planning and Research including, but not limited to:

- expanded uses of anthracite
- increased production of anthracite
- review of applicable mining laws
- coal sizes
- manpower training programs

Funding: Federal/State partnership.

Recommendation 4 - Railroads

All railroad rights-of-way (and if possible the trackage) in the region should be preserved for the foreseeable future to allow flexibility in redeveloping the industry.

Although the condition of rails and rail facilities in the Anthracite Region is deplorable, further deterioration and, particularly, abandonment would effectively restrict anthracite revitalization. The prohibitive costs of trucking coal over long distances and the associated environmental externalities necessitate a viable rail service. It is not only imperative that rail access be maintained to avoid the closure of presently operating collieries; retention is also critical for the potential expansion of the industry.

Recommendation 5 - Laws and Legislation

Review the existing mining laws and, if justified, introduce legislation to amend these to be more compatible with the Anthracite Region. (See comments in this Chapter and the section on legislation in Chapter II.F and the Appendix to Chapter II). Specifically review:

Federal Coal Mine Health and Safety Act, 1969 - Review recommendations of the "Advisory Committee on Safety Standards for Anthracite Coal Mines" and other proposals (including the relevant sections of the Pennsylvania Anthracite Coal Mine Act, 1965) to amend those standards that place undue or excessive burdens and costs on the anthracite operator. Especially review the impact on the industry relating to ventilation, safety catches, automatic couplers and hoisting standards.

Pennsylvania Anthracite Coal Mine Act, 1965 - This Act is generally more compatible with the anthracite mining peculiarities than is the previous act. Section 271, on the use of roof bolts, should be amended to eliminate the unnecessarily stringent procedural requirements.

Pennsylvania Surface Mining Conservation and Reclamation Act, 1971 - The maximum angle of 35 degrees allowed at the highwall is difficult and costly to comply with since the pitches often exceed 45 to 60 degrees. Relaxation of this requirement to permit steeper pit walls would minimize extraction and reclamation costs (see Recommendation 8).

RESEARCH AND DEVELOPMENT RECOMMENDATIONS ("Lower Production and Utilization Costs")

Recommendation 6 - Concentration of mining effort - Minersville Synclinorium

Concentrate all new mining in one area. The advantages of this are:

- Pumping efforts will be mutually supportive and result in much less pumping than in the case of numerous isolated operations.
- Modern preparation plants could serve the entire area.
- Return on investment in railroad trackage and/or highways would be maximized.
- Acid mine drainage treatment facilities can be coordinated.
- The area within the region that is disturbed at any one time is at a minimum, and thus more satisfactory environmentally.

There are several locations where such a concentration of effort could take place. One suggestion is the Minersville Synclinorium between Tremont and Minersville in the Southern Field. The reasons for this choice include:

- There are two billion tons of coal reserves within a surface area of 20 square miles.
- A higher than average proportion of the coal seams are comparatively flat.
- These measures probably have considerably less water than most of the region.
- Schuylkill County owns most of the mineral rights, thus simplifying control of development. The County would also be in a good position to coordinate any necessary zoning change.

This area is then to be mined systematically. First, remove all coal by stripping down to an economical depth. Then, or at the same time as the stripping, the remainder of the reserves, if any, above the valley floor are extracted by drift or tunnel mines. In both the stripping and deep mining most of the water problem could be solved by gravity drainage to treatment plants.

The next stage is to attack the major reserves, that is, those below the valley floor. These may be removed by conventional stripping, "pit" stripping or deep mining. The main problem with these coal measures is the water. Extensive pumping will be necessary at all times. To keep the infiltration to a minimum, all stripped areas will be restored as soon as they have been mined (including any abandoned strip mines). This restoration will not only enhance the value of the surface land, but ensure that surface water is directed into watercourses and does not enter the strip pits and deep mines unnecessarily. Thus the cost of pumping can be substantially reduced.

When deep mining becomes necessary, the method of approach is to sink shafts located somewhere near the middle of the valley floor, and then drive tunnels both ways to intersect all the coal seams in the valley. This coal is either mined on the up or down pitch, depending on what techniques are used. As each level is mined out, the shaft is sunk deeper, another level is developed, and so on.

In this way, the entire resources in the valley will be systematically removed. The same philosophy of concentration of effort can then be applied to other areas, one at a time.

Recommendation 7 - Demonstration Mine

That a Demonstration Mine be developed to apply new techniques and equipment. This would be a State of the Art Mine (SOAM) - evolutionary, not revolutionary.

Administratively, this mine could be operated by the proposed Anthracite Mining Authority. An alternative is to introduce equipment and techniques into an existing mine, in which case some form of cost sharing with a commercial company would be appropriate.

This SOAM would test and evaluate existing equipment, domestic and foreign, as discussed in Chapter V.E. Some modifications to such equipment may be expected to enable it to function effectively in the anthracite conditions.

The Consultant's recommendations for initiating the demonstration mine proposal are as follows:

a. Create a task force to evaluate domestic and foreign extraction developments and uses. The task force report would be directed to applying and/or modifying extractive systems that may have successful application to the anthracite industry.

b. To test the recommendations of the task force and the recommendations for mechanical mining systems in a suitably selected mine.

Table V-1 shows that revitalization of the anthracite industry will eventually require the expansion of deep mining. In fact, deep mining may have to meet more of the demand at earlier dates than shown in the table, especially if the environmental, legal or sociological concerns hinder extensive development of surface mining or if new or expanded anthracite uses are accomplished beyond those projected. In either case research is necessary to avoid the demise of deep mining. Based on the analysis in Chapter V, the Consultant suggests that the initial efforts in implementing the demonstration mine include the following continuous mining system:

1. Development
   Road Header
   Raise Borer

2. Coal Winning
   Shearer Loader Combine

3. Roof Support
   Self-advancing, bidirectional hydraulic chocks

4. Transportation
   Monorail

This system seems to be the most promising coal-winning combination for continuous mining in the steeply pitching anthracite veins.

The application of this system in a moderately-sized deep mine operation, as shown in the sample cost evaluation of the system in Chapter V, would appear to be economically feasible at a run-of-mine value of $18 a ton. Consequently, a testing of this system is justified.

Recommendation 8 - Surface Mining

That research and development to demonstrate the feasibility and possible improvements in surface mining methods be performed in the following areas:

a. A better determination of the extent of coal reserves at depth by a deep drilling program. Initially this should be in selected areas as discussed under Recommendation 6. The advantage of the drilling program would be the determination of the economic and technical limitations of extracting anthracite by deep pit mining methods. As surface mining is generally cheaper and a more competitive extractive method, knowledge of the coal conditions could expand the quantity of coal retrieved by surface mining. The demands on fuel sources, particularly among the utilities, warrants this investigation on the high quality, and potentially competitive, anthracite.

b. In conjunction with the deep pit mining concept, investigate techniques for the stabilization of pit walls. The present methods of stabilization necessary for the protection of men and machinery may require the removal of inordinate amounts of material beyond the pit area. New techniques of rock pinning and other stabilizing development could allow for steeper walls without reducing necessary safety conditions. The potential reduction in extraction costs would be substantial, with the result that greater quantities of strippable reserves might be competitively captured.

c. Investigate improved methods of blasting rock overburden in order to achieve better fragmentation. Since the handling of oversized rocks can occupy upwards of 25 percent of a man day, substantial quantities of coal are not retrieved and, consequently, profits are reduced. The costs associated with handling oversized rocks can amount to direct losses of approximately $75,000 per year for a single machine and operator.

d. Where possible, it is recommended that governmental programs to backfill abandoned strip mines be coordinated to reduce water flow to active deep mines as well as to abate acid mine drainage.

e. There is some problem, due to MESA rules, on the protection of crossing points on trailing cables from electrified strip mining equipment. Development of an economical and safe method of protection for the cables would assist the industry as well as provide obvious safety factors.

Recommendation 9 - Research on Anthracite Uses

That a series of Research and Development projects be initiated to study the possible increase in the use of anthracite. The needs for such studies are discussed in Chapter III.

Gasification

a. Investigate possible improvements of fixed-bed gasifiers for process industries and provide assistance to process industries in retrofitting.

b. Evaluate scaling up the ignifluid process for conversion to a gasifier.

c. Develop gasifiers to burn any type of coal, including run-of-mine.

d. Demonstrate and evaluate the potential of in-situ gasification (and/or steam generation) through controlled mine fires.

Combustion

e. Investigate better methods of burning anthracite, especially in large boilers.

f. Develop methods to solve particulate emission problem.

Industrial Uses

g. Investigate increased use as an industrial carbon.

h. Investigate increased blending with metallurgical coke in ferrous industries and with bituminous coal in the coking process.

Essentially most, or all, of these studies can be organized under the purview of the proposed Anthracite Mining Authority and partially conducted at the proposed Anthracite Research Laboratory (Recommendation 10) facility. In addition, universities and private research firms might also provide substantial contributions to increasing anthracite usage.

The benefits from research on expanded anthracite uses appear to be substantial. Gasification, for instance, is a good illustration. It has been estimated that upwards of 800,000 employees could be laid-off as a result of gas curtailments in the mid Atlantic Region (refer to Chapter III). If, say, only one percent of this number could remain employed with the use of gasifiers to convert anthracite to low-BTU gas, then an estimated $31 million annually could be saved in unemployment benefits alone. (800,000 employees x one percent x $75 weekly unemployment payment x 52 weeks)

Roughly one to one and one-half million tons of anthracite annually would be required for this conversion.

Pennsylvania alone could be faced with 45,000 lay-offs from a gas curtailment estimated at about 20 percent statewide. The magnitude of the natural gas shortage makes imminent the need to develop or improve alternative gas producers in advance of second and third generation gasifiers expected in about 1985. Anthracite is ideal for this use.

As has been noted the utilities offer the best opportunity for revitalizing the anthracite industry. However, if the utilities are to consume large quantities of anthracite, as shown in Chapter III, then improvements in combustion technology is critical. The stark alternative is a further continuation of anthracite decline.

Environmentally, the burning of low sulphur anthracite is preferable and consistent with the effort to improve the quality of life. To the utilities, an 800 megawatt anthracite burning plant, as opposed to a similar size bituminous burning plant, would not require an investment of $40-$80 million for sulphur dioxide scrubbers.

Finally, as illustrated in the example in the following recommendation, an expansion of anthracite use in the coking process has excellent potential. It is conceivable that a ten percent share of the coke making market for anthracite would increase demand by six to eight million tons annually.

In each instance the expansion potential of anthracite use appears to be great, and possibly critically necessary, for many natural gas consuming utilities.

<u>Recommendation 10</u> - Anthracite Research Laboratory

That a study be performed to consider the need for an anthracite testing and research laboratory.

There are several forms this laboratory could take. It could, for example, be confined to the more traditional type of laboratory work such as exploring better methods of combustion, metals beneficiating, and gasification procedures. Or it could also be a hardware evaluation unit, in which case a demonstration mine would come under its jurisdiction. The laboratory, if found feasible, would be the nucleus for conducting research on anthracite extraction and uses and could be administered by the Anthracite Mining Authority.

As a laboratory facility, further research could be conducted on the blending of anthracite and bituminous coals, particularly in the production of metallurgical coke. Various studies have shown that the strength and stability of coke is improved by blending anthracite with bituminous coal. If the anthracite input were to amount to, say, ten percent of the annual coke production, a market for six to eight million tons of anthracite annually would be established. A market of this size would add substantially to the revitalization of the industry.

Research on improving fixed-bed gasifier procedures for process industries would have significant benefits for both the directly dependent natural gas consuming industries and the supporting service and product industries. The very real unemployment situation induced by natural gas cutbacks could be tempered by utiziling coal conversion units (see Recommendation 9). Other research efforts could include:

- methods to develop lower costs of acid mine drainage treatment
- methods to develop lower costs of land reclamation
- methods to economically capture methane gases. (The Pennsylvania State University studies on methane drainage should be evaluated as to their effect on anthracite development and extraction in addition to the possible energy value of the methane).

Further examples of the types and range of research and development (and their associated benefits) that could be carried out by a testing and research laboratory are discussed in Recommendations 8 and 9.

Recommendation 11 - Coal Sizes

That the industry develop standards for the preparation and marketing of coal into fewer sizes. For example, these could be $3\frac{1}{2}$ inches to 1 inch; 1 inch to $\frac{1}{4}$ inch; below $\frac{1}{4}$ inch. This could be a subject for study by the proposed Anthracite Mining Authority.

Two direct benefits to the industry are derived from this suggestion. First, preparation costs would be reduced and, second, storage requirements and costs would also be less. Elimination of a number of sizes eliminates an equal number of processing steps. Since slow selling sizes frequently must be sold at cut-rate, and since the markets do not indicate a need for many of the sizes, the operators' profits would be greater with a reduction in the gradations.

Of equal importance to both the operator and a potential stockpiling program are the excessive storage requirements with current sizes. If the stockpile is to operate efficiently it would be directly beneficial to have the least number of separate stores as would be compatible with market needs. As noted, it would appear that three to, perhaps, five sizes would be sufficient.

Recommendation 12 - Manpower Training Program

In order to overcome the shortage of labor in both the strip and deep mining portions of the industry, a training program should be initiated.

The programs that have been started by the Commonwealth of Pennsylvania and some of the Vo-Tech schools should be encouraged and intensified. In this connection, more on-the-job training, or at least more exposure to actual conditions, is considered vital.

As new mines are developed, these programs should be expanded into systematic on-the-job training. As the pool of trained persons is developed, cadres of skilled workers would be assigned to new mines to assist in development and training.

It is further recommended that the universities with mining schools evaluate the adequacy of the number of their graduates, especially those interested in coal mining, and adjust their programs accordingly. It is recommended that optional courses in anthracite mining be offered.

Training courses should not overlook the management shortage that will be accentuated as production rises.

Once again this recommendation could incorporate the involvement of the Anthracite Mining Authority. As future manpower needs are identified, the Authority could propose the types of skills required and the direction the training or educational program should take. The administration of this and the various other recommendations under the aegis of the Authority would assure the necessary coordination in achieving a balanced and directed revitalization.

\- - - - - - - -

Each of the above recommendations separately done would tend to improve the chances for achieving anthracite revitalization. Some, of course, would have a greater impact than others. For instance, the Consultant believes that a stockpiling program would have a very substantial impact on market stability. Combustion improvements, research on possible uses and development of mechanical mining systems would also substantially improve the competitive posture of the industry.

The recommendations, nonetheless, are presented as mutual activities. That is, the potential impact of all the activities is greater than the sum impact of the individual activities. In this light, the Consultant proposes that all or most of these recommendations be implemented.

It is further suggested that immediate attention and, where possible, immediate action be given to these recommendations. Whereas some of the recommendations are of a more imminent consideration than others (for example, manpower training could be partially delayed to more fully evaluate the skills that future mining efforts will demand), the greatest impact can be assured by quick action.

APPENDICES

INTERVIEWS AND CONTACTS

The following is a list of interviews and other contacts. In the case of most of the utilities and industries shown, a letter similar to that shown on page P-A-13 was mailed to the president of the company. As will be seen, response was excellent. The notation "letter" indicates that the initial reply was an adequate response, and no further contact was deemed necessary.

Many interviews were, due to time and distance constraints, made by telephone. Both the telephone and personal interviews were, almost without exception, very fruitful. Those interviewed responded willingly and openly, and the information gathered has been used in developing this report. As will be noted elsewhere, there is a great interest in keeping the anthracite industry alive and well.

	Nature of Contact	Person(s) Interviewed
U.S. GOVERNMENTAL AGENCIES		
U. S. Railway Association Washington, D.C.	Interview	Harry R. Davis, Director of Facilities, Education and Planning
U. S. Bureau of Mines Wilkes-Barre, Pa.	Interview	Charles S. Keubler Ralph H. Whaite Wilbert Malenka Ivor Williams
U. S. Bureau of Mines Washington, D.C.	Interview	Lowell Gibbs, Staff Engineer
Interstate Commerce Commission, Washington, D.C.	Telephone	Mr. McCarthy, Section of Tariffs
U. S. Geological Survey Harrisburg, Pa.	Telephone	Douglas Growitz, Ground Water Section
Defense Fuel Supply Center Alexandria, Va.	Telephone	Erik J. Ortmann
Mine Enforcement and Safety Administration, Wilkes-Barre, Pa.	Interview	John Shutack, Director Jerry Fortney, Ass't Director and Others

	Nature of Contact	Person(s) Interviewed
Office of Coal Research, Washington, D.C.	Interview	William G. Wilson, Paul Musser, Mr. Wheeler, Mr. Grua
Appalachian Regional Commission, Washington, D.C.	Interview	Dr. David R. Maneval
PENNSYLVANIA GOVERNMENTAL AGENCIES		
Office of State Planning and Development	Interview	Robert Sidman, Coordinator Fritz Fitchner Robert Dennis, Comprehensive Planning Supervisor Martin Margolis, Special Assistant
Pennsylvania Topographic and Geologic Survey	Interview	William Edmunds, Chief Coal Geologist
Governor's Energy Council	Interviews (3)	William B. Harral, Executive Director Hobart King, Ray Holst
Public Utility Commission	Interviews (2)	Ray A. Peteritas John Keiter, Bureau of Transportation
Department of Transportation	Interview	Edson L. Tennyson, Deputy Secretary for Local and Area Transportation
Department of Environmental Resources	Interview	Walter N. Heine, Associate Deputy Secretary, Mines and Land Protection Catherine Miles, Statistical Division
Bureau of Deep Mine Safety	Interviews	James J. Shober, Director William Darkes, Admin. Assistant Inspectors - Steven Boyer, Leon Brass, Joseph Hallaburda, Arthur Hand, Clarence Kashner, Clarence Miller, Leonard Rogers Electrical Inspector - William Buggy

	Nature of Contact	Person(s) Interviewed
Bureau of Surface Mine Reclamation	Interview	George Stirling, Chief Inspectors - Tony Latz, William D. Manner (Rt'd), Robert Whitmer
Department of Commerce	Interview	Robert D. Laughlin, Bureau of Scientific and Technical Development Robert Smigel, Director, Bureau of Statistics
Department of Education	Interview	Dr. M. W. Podvia, Chief, Retraining Section, Bureau of Continuing Education
Industrial Development Authority	Interview	John S. Cole, Executive Director Ronald A. Lloyd, Economic Development Loan Specialist
Department of Community Affairs	Telephone	Thomas Lynott, Regional Coordinator, Bureau of Human Resources
UTILITIES		
Atlantic City Electric Co.	Letter	H. C. Schwemm, Jr., Superintendent, Power Economics
Baltimore Gas & Electric Co.	Telephone	A. E. Lundvall, Vice President, Supply
Central Hudson Gas & Electric Company		No reply
Delmarva Power & Light Co.	Telephone	Roger Campbell, Ass't. to Vice President of Power Generation
Duquesne Light Co.	Letter	Stanley G. Schaffer, President
General Public Utilities		
Jersey Central Power & Light Company	Interview	J. W. Peters, Research Engineer
Metropolitan Edison Co.	Letter	J. F. McConnell, Manager, Research and Development
Pennsylvania Electric Co.		

	Nature of Contact	Person(s) Interviewed or Signers of Letters
New York State Electric & Gas Company	Telephone	A. R. Boyd, Vice President of Purchasing
Niagara Mohawk Power Co.	Letter	H. D. Philipp, Director, Research and Development
Northeast Utilities Service Company	Letter	William G. McCauley, Manager of Fuel Supply
Orange & Rockland Utilities Co.	Telephone	John Small, Ass't to Senior Vice President
Pennsylvania Gas & Water Co.		No reply
Pennsylvania Power & Light Co.	Interview	John T. Kaufman, Vice President, System Power and Engineering Dr. Heinz G. Pfeiffer, Manager, Technology and Energy Assessment
Philadelphia Electric Co.	Interview	J. L. Hankins, Vice President, Electric Production Department
Pottsville Gas Co.	Letter	John H. Ware, 3rd., President
Public Service Electric & Gas Co., Newark, N.J.	Letter	Robert M. Crockett, Vice President - Fuel Supply
Rochester Gas & Electric Co.	Letter	R. A. Conversi, Fuel Buyer
United Gas Improvements Corp.	Interview	Richard Demmy, Vice President Robert Casselberry

INDUSTRY (OTHER THAN COAL)

Alabama Byproducts Corp. Birmingham, Alabama		No reply
Aluminum Company of Canada, Ltd., Montreal, Canada	Letter	G. W. Brian Rickerby,
Allen Wood Steel Co. Conshohocken, Pa.	Telephone	A. Lagomarsino, Director of Planning

	Nature of Contact	Person(s) Interviewed or Signers of Letters
Allied Chemical Corp. New York City	Letter	H. W. Schultze, Group Vice President
Bethlehem Steel Corp. Bethlehem, Pa.	Interview	L. B. Gray, Jr., Vice President and General Manager of Coal Mining J. J. Shigo, III, Ass't Manager for New Projects Development A. McDonald Keith Barlow
Carbidie McKeesport, Pa.	Letter	E. S. Hilty, General Manager
The Carborundum Company Niagara Falls, N.Y.		No reply
Coalcon Corp. New York City		No reply
Coplay Cement Co. Nazareth, Pa.	Interview	Dean E. Sandbrook, Vice President
E. I. du Pont de Nemours & Co., Wilmington, Del.	Telephone	H. G. Shulby, Manager, Energy Section
FMC Corporation Media, Pa.	Letter	R. S. Johnson, Purchasing Agent
Glen-Gery Corporation	Interview	R. W. Dammann, Vice President
Great Lakes Carbon Company New York City	Telephone	F. B. Fontana, Manager, Supply and Distribution
Hercules Cement Company	Telephone	Office of C. C. Amy, Purchasing Manager
Hooker Chemical Corporation Niagara Falls, N.Y.	Letter	N. H. Kirchgessner, Director, Energy Planning & Procurement
Jones & Laughlin Steel Corp. Pittsburgh, Pa.	Telephone	Richard Lukehart, Manager of Production Materials
Koppers Company Pittsburgh, Pa.	Telephone	Lawrence Nagle, Manager, Foundry Products

	Nature of Contact	Person(s) Interviewed or Signers of Letters
Lehigh Portland Cement Co.	Telephone	R. E. Jones, Director of Purchasing
Lone Star Industries, Inc.	Telephone	Mr. Brienig, Purchasing
Lukens Steel Co. Coatesville, Pa.	Telephone	Edmond Pfeiffer, Director of Purchasing
Medusa Cement Co. York, Pa.	Letter	Daniel E. Somes, Ass't Vice President, Manufacturing
Merck & Co., Inc. Rahway, N.J.	Telephone	J. L. McIntosh, Purchasing Agent
New Jersey Zinc Co. Bethlehem, Pa.	Interview	A. E. Owens, Ass't Manager, Purchasing
Philadelphia Coke Co.	Telephone	William Nordell, Purchasing Agent James P. Templin
Phoenix Steel Corporation Phoenixville, Pa.		No reply
P. H. Glatfelter Spring Grove, Pa.	Letter	R. S. Leonard, Purchasing Director
Quebec Iron & Titanium Corp. Quebec, Canada	Interview	J. M. Herndon, General Manager A. P. T. Edwards, Director of Materials and Traffic
Union Carbide Corporation New York City	Telephone	A. L. Cerda, Purchasing
United States Steel Corp. Pittsburgh, Pa.	Interviews	J. G. Munson, Ass't to Exec. Vice Pres., Coke & Coal Chemical Operations Mr. Boisture, Purchasing
Wyandotte Corporation Wyandotte, Mich.	Telephone	Richard Reddington, Purchasing Manager

	Nature of Contact	Person(s) Interviewed
COAL INDUSTRY		
Wilmot Engineers, White Haven	Interview	M. R. Jeppsen, Chief Engineer
F. & D. Coal Sales	Interview	Dominic Forte - Broker
Blue Coal Corporation	Interview	Charles Zink
Swatara Coal Company	Interview	William Parker, President Frank Parker, Secretary
Paul Slatery	Interview	Paul Slatery - Broker
Hegins Mining Company	Interview	Earl Kiefer, President
Kerris & Helfrick, Inc.	Interview	Robert Kerris, Corp. Officer
Bush Mining Company	Interview	Earl Bush, Owner
Knorr Coal Company	Interview	Leroy Knorr, Jr., Partner
Lucas Mining Company	Interview	Larry Lucas, Partner
M & K Coal Company	Interview	Russel Kerstetter, Partner
Colket Coal Company	Interview	John Messaros, Partner
Leroy Snyder Coal Company	Interview	Leroy Snyder, Owner
Mercury Coal Company	Interview	Leon Richter, Corp. Officer
Tracy Coal Company	Interview	Mike Dudash, Partner
Leon Kocher Coal Company	Interview	Robert Rissinger, Corp. Officer
Superior Coal Company	Interview	Roy Blyler, Owner
Pine Creek Coal Company	Interview	Ronald Klinger, Owner
Manbeck Dredging Company	Interview	Charles Manbeck, Owner
New St. Nicholas Breaker	Interview	Inspector Robert Whitmer
Beechwood Cleaning Plant	Interview	Inspector Robert Whitmer

	Nature of Contact	Person(s) Interviewed
Pine Forest Cleaning Plant	Interview	Inspector Robert Whitmer
Ryan Contracting Company	Interview	James V. Ryan, Jr., Corp. Officer
Acme Coal Company	Interview	Joe Reho, Partner
D & R Coal Company	Interview	Tony Donofrio, Partner
Harner Coal Company	Interview	Roy Harner, Partner
Hatter Coal Company	Interview	Jacques Hatter, Corp. Officer
Kintzel Brothers	Interview	Nathan Kintzel, Partner
Koppenhaver Coal Company	Interview	Howard Koppenhaver, Owner
P & M Coal Company	Interview	Warren Porter, Partner
S & T Coal Company	Interview	Peter Poletti, Partner
S & K Coal Company	Interview	Palmer Klinger, Partner
Shomper Coal Company	Interview	Russell Shomper, Partner
Smeltz Coal Company	Interview	Clair Schwalm, Partner
Underkoffler Coal Company	Interview	Glenn Underkoffler, Partner
Williamson Coal Company	Interview	A. R. Williamson, Corp. Officer
Wilson Coal Company	Interview	Edward Twiggar, Superintendent
Marlin Zimmerman Coal Co.	Interview	Marlin Zimmerman, Owner
Franklin Coal Company	Interview	Frank Miller, President
Meadowbrook Coal Company	Interview	Leslie Kimmel, Owner
Oakwood Coal Company	Interview	David Deaven, Owner
Schneck Coal Company	Interview	Thomas Schneck, Owner
Bell Coal Company	Interview	John Butcavage, Owner
Dale Coal Company	Interview	John Schumacher, Superintendent

	Nature of Contact	Person(s) Interviewed
Williams & Joy	Interview	Evan Williams, Partner
Bernitski Bros. Coal Co.	Interview	George Stenulis, Partner
K & K Coal Company	Interview	Ben Kuperavage, Partner
Pagnotti Enterprises	Interview	James Tedesco, Vice President
Fireside Mining Company	Interview	Marvin Kimmel, Superintendent
Zekrewsky Coal Company	Interview	Peter Zekrewsky, Owner
Locustdale Mining Company	Interview	Harry David, Partner
Pewor Coal Company	Interview	Walter Pewor, Owner
Southern Carbon Corporation	Interview	George Clark, President
Beltrami Enterprises, Inc.	Interview	Joseph Beltrami, Corp. Officer
Brook Contracting Company	Interview	George Racho, Corp. Officer
Glen Burn Colliery, Inc.	Interview	Joseph Parker, Superintendent
Harman Coal Company	Interview	John Harman, Owner
Metzinger Coal Company	Interview	Donald Metzinger, Owner
North Line Coal Company	Interview	C. Wayne Troxell, Superintendent
Olenick Bros. Coal Company	Interview	Nick Olenick, Partner
Sharp Mountain Coal Company	Interview	Norman Wolf, Partner
Sunshine Coal Company	Interview	Ralph Steinhart, Retired Owner
W. & W. Construction Company	Interview	Joseph Walacavage, President
K & S Coal Company	Interview	Allen Kramer, Partner
Palcovich Coal Company	Interview	Paul Palcovich, Owner
Wolfgang Bros. Coal Company	Interview	Lester Wolfgang, Partner
S & N Coal Company	Interview	Skrepnick & Niadna, Partners

	Nature of Contact	Person(s) Interviewed
Donaldson Coal Company	Interview	Bob Wolfgang, Partner
K.H. & K. Coal Company	Interview	Sorobich and Zabrewsky, Partners
P and H Coal Company	Interview	Walter Pewor, Owner
Walaitis Coal Company	Interview	John Walaitis, Owner
Mountain Top Coal Company	Interview	Bill Vassay, Owner
Woratyla Coal Company	Interview	Andrew Woratyla, Owner
Klinger Coal Company	Interview	Earl Klinger, Owner
LABOR UNIONS AND ASSOCIATIONS		
United Mine Workers of America	Interview	Walter Kraska, President William Savitsky, District President
Independent Miners and Associates	Interview	Clyde Maskamer, President Henry Bowman, Vice President
Independent Miners, Breakers & Truckers Association	Interview	William Heitzman
UNCLASSIFIED		
The Pennsylvania State University	Interview	Dr. Richard Gordon, Chairman, Mineral Economics Dept., College of Earth & Mineral Sciences
	Interview	Dr. Robert Essenhigh, Combustion Laboratory Dr. Nicholas Miskovsky Dr. Leonard Austin
	Interview	Dr. Robert Stefanko, Ass't Dean, College of Earth & Mineral Sciences
Economic Development Council of Northeastern Pennsylvania	Interviews	Walter Chappel Austin Burke

	Nature of Contact	Person(s) Interviewed
Reading Company	Telephone	A. W. Nemenz, Asst. Vice President A. V. Nowakowski, Manager, Coal Marketing
MMI Preparatory School (Mining & Mechanical Inst.) Freeland, Pa.	Letter	Ralph E. Whitmer, Librarian
Penn Central Railroad Philadelphia, Pa.	Letter	Mr. J. T. Bodel, Director, Coal and Ore Pricing
	Telephone	Charles Wolfinger, Asst. Vice President, Coal and Ore
Central Railroad of New Jersey Newark, N.J.	Letter	P. J. Turnbach, Manager - Pricing
Lehigh Valley Railroad	Telephone	Mr. Storr
Erie Lackawanna Railway Co. Hoboken, N.J.	Telephone	R. J. O'Grady, Coal Traffic Manager
Delaware & Hudson Railroad Albany, N.Y.	Telephone	Michael Gilcrest T. O'Brien
Embassy of France Washington, D.C.	Letter	Reply from French Mining, Chemical and Allied Industries, Mr. J. Faucounau
Embassy of Israel Washington, D.C.	Letter	Chaim Even-Zohar, Assistant Economic Counselor
Embassy of Italy Washington, D.C.	Telephone	Mr. Ricci
Embassy of Japan Washington, D.C.	Letter	Kathy Imler
Embassy of Yugoslavia Washington, D.C.		No reply
Smithsonian Institution Washington, D.C.	Interview	Dr. John Hoffman
Coal Mine Compensation Rating Bureau of Pennsylvania Harrisburg, Pa.	Interview	Gene Buzby, General Manager

	Nature of Contact	Person(s) Interviewed or Signers of Letters
Pennsylvania Coal Mining Association	Interview	Franklin H. Mohney
Keystone Bituminous Coal Association	Interview	Henry Brown
Concurrent Studies		
HRB-Singer	Telephone	William Knuth, Project Manager
North American Galis Corp. Morgantown, W. Va.	Telephone	Alexander Galis, President
Cobbs Engineering Co. Tulsa, Oklahoma	Telephone	James Cobb, Vice President

337

berger associates

ARCHITECTS ■ ENGINEERS ■ PLANNERS ■ ECONOMISTS

P-4090/P-735

July 24, 1974

Mr. Jack K. Busby, President
Pennsylvania Power & Light Company
901 Hamilton Street
Allentown, Pa. 18101

Dear Mr. Busby:

This company has been retained by the U. S. Bureau of Mines to study the revitalization of the anthracite industry in Pennsylvania.

In the course of the study, it will be necessary to determine what can be done to increase the production of anthracite at a cost that is economically attractive to potential purchasers.

At the same time, we have to attempt to identify potential markets so as to determine a reasonable rate of production for the anthracite industry.

As you will readily appreciate we have something of a "chicken and egg" situation, and we are endeavoring to obtain from potential users not commitments but serious indications of possible future uses of anthracite. I might emphasize that we are advocating long term commitments so that both the producers and the users will be able to plan on a continued flow of coal.

As this matter could be of considerable interest and benefit to the Pennsylvania Power & Light Company, especially as your service area coincides very closely with the Anthracite Region, we are addressing this letter directly to you, with the request that we may meet either with yourself or with whomever you may designate, to discuss this matter in more detail.

We look forward to your assistance and cooperation in this matter.

Very truly yours,

F. Heywood Marsh

F. Heywood Marsh
Senior Vice President

FHM/mrp

c.c. Mr. Ralph H. Whaite

P.O. BOX 1943 ■ HARRISBURG, PENNSYLVANIA 17105 ■ TELEPHONE (717) 238-9471
OFFICE ■ 101 ERFORD ROAD, CAMP HILL, PENNSYLVANIA

BIBLIOGRAPHY

1. ECONOMICS

Albright, Joseph, "A Hell of a Way to Run A Government", The New York Times Magazine, November 3, 1974.

"Anthracite Mining, 1972", Census of Mineral Industries, U. S. Department of Commerce, Bureau of Census.

Bhatt, H. G., The Economics of Coal Mine Drainage Treatment, Michael Baker, Jr., Inc., Beaver, Pennsylvania, November, 1973.

"Coal for the 70's", Pennsylvania Governor's Energy Council, Ernest Kline, Chairman, 1974.

"Coal's Partner", Forbes, Vol.110, November 15, 1972, p.46.

Deasy, G. F., et al, "Atlas of Pennsylvania Coal and Coal Mining, Part II, Anthracite", Bulletin of the Mineral Industries Experiment Station, (No.80), College of Mineral Industries, The Pennsylvania State University, 1963.

"Evaluation of the Secretary of Transportation's Rail Services Report", Interstate Commerce Commission, Washington D. C., May 2, 1974.

"The Foreign Market Potential for United States Coal, Vol.IV", Research and Development Report #3, Office of Coal Research, 1963.

Freight Commodity Statistics, Interstate Commerce Commission, 1972.

General Social and Economic Characteristics, U. S. Department of Commerce, Bureau of Census, Vol.40, 1970.

McGuire, E. J., "Do-It-Yourself Kit Simplifies Shaft-Sinking Cost Estimates", Coal Age, February, 1969, p.92.

Merritt, Paul C., "West Virginia Miners Talk About Problems in Opening New Mines", Coal Age, December, 1974, p.75.

Minerals Yearbook, U. S. Bureau of Mines, selected years.

Morton, Rogers C. B., Secretary of the Interior, News Release, March 29, 1974.

Moyer, R., Competition in the Midwestern Coal Industry, Harvard University Press, Cambridge, 1964.

"Pennsylvania Action - A Program for Coal Development in the State", Coal Age, June, 1974, p.76.

"Pennsylvania Anthracite Weekly", Mineral Industries Surveys, U. S. Bureau of Mines, Selected Issues.

"Pennsylvania Coal", Pennsylvania Governor's Energy Council, Ernest Kline, Chairman, 1974.

Perry, Harry, "Excerpts from the Cornell Workshops on the National Energy Research and Development Program".

Report of the Anthracite Coal Industry Commission, Pennsylvania Anthracite Coal Industry Commission, June 30, 1938, p.564-5.

Schenck, G. H., et al, The Economic Importance of the Coal Industry to Pennsylvania, Pennsylvania Coal Research Board, SR-64, 1967.

"Testimony of the Economic Development Council of Northeastern Pennsylvania on Regional Rail Reorganization", Economic Development Council of Northeastern Pennsylvania, March 4, 1974.

Vaughan, J., "Anthracite", Mineral Facts and Problems, U. S. Department of the Interior, Bureau of Mines, 1965.

Wimpfen, S. P. "Mine Costs and Control", SME Mining Engineering Handbook, 1973.

2. LABOR RELATIONS AND TRAINING

"Aboveground School for Underground Workers", Coal Age, October, 1970, p.80.

"An Institute for Training Machine Operators Opens in Pennsylvania", Coal Age, May, 1972, p.81.

"Anthracite Wage Agreement of April 16, 1972", United Mine Workers of America, District 25.

Ashcraft, John, et al, "The West Virginia Miner Training, Education and Certification Act", Coal Mining and Processing, December, 1974, p.62.

Blakely, J. Wes, "Individual State, Company, and School Efforts Significant", Coal Mining and Processing, December, 1974, p.57.

________. "The Manpower Scene: Training and Development", Coal Mining and Processing, December, 1974, p.52.

Cornforth, Carol, "Kentucky College Offers Associate Degrees in Mining and Reclamation", Coal Mining and Processing, December, 1974, p.60.

Hurley, James H., "Training Important at Florence since Company's Beginning", Coal Mining and Processing, December, 1974, p.55.

Maneval, Dr. David R., et al, "New Techniques Needed to Attract, Hold Manpower", Coal Mining and Processing, December, 1974, p.53.

"MDTA Training at N. Schuylkill County AVTS", Progress Report Miner I Program, Pennsylvania Department of Labor and Industry, October 25, 1974.

"New Plant Enhances Anthracite Marketing Flexibility", Coal Age, June, 1970, p.62.

"Seminar Tackles Technical Training Needs and Problems", Coal Age, June, 1974, p.130.

Smith, Paul, Secretary of the Pennsylvania Department of Labor and Industry, Working Papers for the Manpower Task Force, "Coal for the 70's", 1974.

"Training Program for the Pennsylvania Coal Industry, Bituminous and Anthracite", Governor Milton J. Shapp Master Plan.

"Trained Skilled Mining Techniques, Problems and Suggestions", Educational Projects, Inc., Prepared for the Pennsylvania Department of Commerce, April 26, 1974.

3. HEALTH AND SAFETY

"Analysis of Exposure Under Pennsylvania Act 337 Mine Occupational Disease", J. Huell Briscoe & Associates, Inc. (Chicago, Illinois), May, 1973.

Curth, E. A., "Causes and Prevention of Transportation Accidents in Bituminous Coal Mines", U. S. Bureau of Mines, IC 8506, 1971.

Chironis, N. P., "New Instrument-Controlled Vehicles May Soon Improve Safety in Mines", Coal Age, November, 1973, p.52.

________. "Jim Day's MESA. . . A Dynamic Organization Expanding its Functions in Health and Safety", Coal Age, November, 1974, p.74.

Davis, Harold, "Taking Reasoned Steps to Increase Productivity and to Improve Safety", Coal Age, February, 1973, p.111.

"Discuss New Concepts in Health, Safety and Research", Coal Age, January, 1970, p.98.

"Focus on Safety", Coal Age, October, 1969, p.168.

Forbes, J. J., et al, Coal Miners Safety Manual. A Handbook for Miners, 1942.

McCartney, James R., "Safety in the Coal Industry", Coal Age, August, 1964, p.62.

Merrit, Steven E., "Miner-Bolter Boosts Productivity and Safety", Coal Age, November, 1969, p.54.

"Mining Guidebook -- Special Report on Safety", Coal Age, July, 1973.

"Safety", Coal Age, October, 1970, p.164.

"Safety in 1969", Coal Age, February, 1970, p.77.

"Safety in 1970", Coal Age, February, 1971, p.77.

"Speak Up for Safety: NSC Theme", Coal Age, December, 1969, p.94.

Stahl, R. W., et al, "Recommended Safety Precautions for Active Coal Stockpiling Operations", U. S. Bureau of Mines, IC 8256, 1965.

Walrod, G. H., et al, "Analyzing Development Roof Falls", Coal Age, March, 1971, p.103.

4. COAL PROPERTIES AND PREPARATION

Abel, W. T., et al, Dry Separation of Pyrite from Coal, Paper delivered at the 162nd National Meeting ACS, Division of Fuel Chemistry, Washington, D. C., September 13-17, 1971.

"Analysis of Tipple and Delivered Samples of Coal, Collected During Fiscal Year 1969", U. S. Bureau of Mines, RI 7346, 1970.

Babcock, Allan, "Fly Ash Achieving Dramatic Success in Reclaiming Coal Waste Piles", Coal Age, April, 1973, p.88.

Brady, G. A., et al, "Dewatering Anthracite Slurry", U. S. Bureau of Mines, RI 7012, August, 1967.

________. "Properties of Anthracite from the Bottom Ross Bed", U. S. Bureau of Mines, RI 7086, 1968.

Cavallaro, J. A., et al, "Froth Flotation Washability Data of Various Appalachian Coals Using the Timed Release Analysis Techniques", U. S. Bureau of Mines, RI 6652, 1965.

"Seely W. Mudd Series", Coal Preparation, American Institute of Mining and Metallurgical Engineers, New York, 1943.

Coal Preparation Manual 572, McNally Pittsburg Manufacturing Corp., Pittsburg, Kansas.

Demeter, J. J., et al, "Sulfur Retention in Anthracite Ash", U. S. Bureau of Mines, RI 7160, July, 1968.

Deurbrouck, A. W., et al, "Performance Characteristics of Coal Washing Equipment: Concentrating Tables", U. S. Bureau of Mines, RI 6239, 1963.

________, et al, "Performance Characteristics of Coal Washing Equipment: Sand Cones", U. S. Bureau of Mines, RI 6606, 1965.

________, et al, "Performance Characteristics of Coal Washing Equipment: Dense-Medium Cyclones", U. S. Bureau of Mines, RI 7673, 1972.

Eckerd, J. W., et al, "Anthracite Preparation - Past and Present", Paper presented at AIME Annual Meeting, New York, Preprint No.71-F-57, 1-4 March, 1971.

________. "Crushing Chestnut-Size Anthracite to Produce Buckwheat No.1 and Rice Sizes", U. S. Bureau of Mines, RI 5578, 1960.

________, et al, Hollow-Core Anthracite Briquets as Blast Furnace Fuel", U. S. Bureau of Mines, RI 7157, July, 1968.

Ferrighetto, J., et al, The Crushing of Anthracite, Pennsylvania Coal Research Board, SR-1, 1957.

"Fly Ash Gives Plants a Big Boost in Growth", Coal Age, December, 1972, p.102.

Gandrund, B. W., et al, "Recent Development in Combination Cleaning and Dewatering of Fine Sizes of Coal", U. S. Bureau of Mines, RI 4707, 1950.

Hummer, E. D., "Modern Approach to Plant Refuse Disposal", Coal Age, June, 1969, p.74.

Huff, W. R., et al, "Flow Properties of Powdered Coal-Water Slurries", U. S. Bureau of Mines, RI 6706, 1965.

Ingersoll, D. E., et al, "Washability Characteristics of Mammoth and Holmes Vein Anthracites", U. S. Bureau of Mines, RI 5569, 1960.

Konshesky, J. L., et al, "Particle-Size Reduction of Coal by Attrition in a Tube", U. S. Bureau of Mines, RI 5824, 1961.

Liu, H. S., et al, Changes in the Physical Properties of Anthracite Upon Heat Treatment, Pennsylvania Coal Research Board, SR-40, 1963.

MacCartney, John C., "Pennsylvania Anthracite Refuse. A Survey of Solid Waste from Mining and Preparation", U. S. Bureau of Mines, IC 8409, 1969.

"Mining and Preparation in 1971", Coal Age, February, 1972, p.66.

Munn, K. J., et al, An Investigation of the Cyclone for Fine Coal Cleaning, Pennsylvania Coal Research Board, SR-45, 1964.

"New Concepts and Equipment Take Hold in Mining and Preparation", Coal Age, February, 1973, p.94.

Palowitch, E. R., et al, "New Improvements Shown in Coal Preparation", Mining Engineer, Vol.16, No.2, February, 1964, p.89-90.

Parks, B. C., "Origin, Petrography and Classification of Coal", Chemistry of Coal Utilization, John Wiley & Sons, Inc., 1963.

"Preparation, Quality Control, Environmental Protection", Coal Age, October, 1970, p.137.

"Preparation: Quality Products", Coal Age, October, 1969, p.150.

Ramsey, J. W., et al, "Relation of Density and Porosity Data to Structural Features of Anthracite", U. S. Bureau of Mines, RI 6657, 1965.

Rao, P. D., et al, The Crushing of Anthracite with an Impactor Type Crusher, Pennsylvania Coal Research Board, SR-8.

"Roundup of What's New in Mining and Preparation", Coal Age, February, 1974, p.74.

Sanner, W. S., "The Preparation of Low-Ash-Content Anthracite", Transactions AIME, Vol.244, September, 1969, p.268-276.

________. "Ultrafine Grinding of Anthracite", U. S. Bureau of Mines, RI 7170, 1968.

________, et al, "Agglomerating Anthracite for Metallurgical Fuels", U. S. Bureau of Mines, RI 5843, 1961.

________. "Calcination of Raw and Agglomerated Anthracite in a Vertical Shaft Retort", U. S. Bureau of Mines, Open File Report 6-66-Central Library, W.S. Department of the Interior.

________. "Preparation Characteristics of Pennsylvania Anthracite from the Bottom Red Ash Bed, Northern Field", U. S. Bureau of Mines, RI 6989, July 1971.

Solaski, M., et al, "Cleaning Unsized Fine Coal in a Dense Medium Cyclone Pilot Plant", U. S. Bureau of Mines, RI 6274, 1963.

Young, W. H., et al, "Coal Mining and Cleaning Equipment", Coal Age, February, 1965, p.86-88.

Zeilinger, J. E., et al, "Preparation Characteristics of Pennsylvania Anthracite from the Kidney Seam, Northern Field", U. S. Bureau of Mines, RI 7364, 1970.

5. ANTHRACITE RESERVES AND DEEP MINE POOLS

Ash, S. H., et al, "Flood Prevention Anthracite Mines, Western Middle and Southern Fields", U. S. Bureau of Mines, Bulletin 546, 1955.

________, et al, "Inundated Anthracite Reserves: Eastern Middle Field of Pennsylvania, U. S. Bureau of Mines, Bulletin 491, 1950.

________, et al, "Water Pools in Pennsylvania Anthracite Mines", U. S. Bureau of Mines, Technical Paper 727, 1949.

________, et al, "Data on Pumping at the Anthracite Mines of Pennsylvania", U. S. Bureau of Mines, RI 4700, 1950.

Ashley, George H., "Anthracite Reserves", Pennsylvania Topographic and Geologic Survey, Progress Report 130, 1945.

Ashmead, Dever C., "Anthracite Losses and Reserves in Pennsylvania", Pennsylvania Topographic and Geologic Survey, Bulletin M-8, 1926.

Edmunds, William E., "Coal Reserves of Pennsylvania: Total, Recoverable and Strippable (January, 1970)", Pennsylvania Topographic and Geologic Survey, Information Circular 72, 1972.

Dierks, H. A., et al, "Mine Water Control Program, Anthracite Region of Pennsylvania: July 1955 - December 1961", U. S. Bureau of Mines, IC 8115, 1962.

Gait, G. B., "Microfilming Maps of Abandoned Anthracite Mines in the Lackawanna Basin, Northern Anthracite Field", U. S. Bureau of Mines, IC 8453, 1970.

________. "Microfilming Maps of Abandoned Anthracite Mines in the Western Middle Anthracite Field", U. S. Bureau of Mines, IC 8519, 1971.

Hollowell, Jerrold, R., "Hydrology of the Pleistocene Sediments in the Wyoming Valley", Water Resources, Report 28, 1973.

McCartney, J. C., et al., "Pennsylvania Anthracite Refuse - A Survey of Solid Waste from Mining and Preparation", U. S.Bureau of Mines, IC 8409, 1969.

Sisler, James D., et al, "Anthracite Culm and Silt", Pennsylvania Topographic and Geologic Survey, Bulletin M-12, 1928.

Whaite, R. H., "Microfilming Maps of Abandoned Anthracite Mines of the Eastern Middle Field", U. S. Bureau of Mines, IC 8274, 1965.

Wood, Gordon H., Jr., et al, "Geology of the West Central Part of the Southern Field and Adjoining Areas, Pennsylvania", U. S. Geological Survey, Professional Paper 602, 1969.

6. GENERAL ENERGY

Annual Report 1973-74, Coal Technology, Key to Clean Energy, U. S. Department of the Interior, Office of Coal Research, February 15, 1974.

Applicability of the Meyers Process for Chemical Desulfurization of Coal, Initial Survey of Fifteen Coals, TRW Systems Group, Prepared for the U. S. Environmental Protection Agency, April, 1974.

Baker, A. F., et al, "Experimental Study of Pressure Drop Across Fixed Beds of Anthracite Briquets and Blast Furnace Materials", U. S. Bureau of Mines, RI 6945, May, 1967.

Boyd, Noel, F., "Coal Conversion Processes Loom Big as a Source of Hydrocarbon Fuels", Coal Age, September, 1974, p.34.

Chironis, N. P., "What's New in Coal Research Revealed at International Meeting", Coal Age, December, 1973, p.67.

"The Coal Energy Dilemma . . . Independents are Feeling a Squeeze", Coal Age, November, 1971, p.82.

"Coal for the 70's", A Pennsylvania Action Conference, Harrisburg, Pennsylvania, April 24, 1974.

Coal Utilization Symposium - Focus on SO_2 Emission Control, Coal and the Environment Technical Conference, Louisville, Kentucky, October 22-24, 1974.

Complying with Sulfur Dioxide Regulations, Noyes Data Corporation, Park Ridge, New Jersey, 1972.

Dammann, R. W., "Guaranteed Gas Now", Paper delivered at the Coal for the 70's Conference, Harrisburg, Pennsylvania, April 24, 1974.

Deasy, G. F., et al, Fuel Competition in Pennsylvania's Electric Generating Industry, Topographic and Geologic Survey, Bulletin M-44, Pennsylvania Department of Internal Affairs, Harrisburg, Pennsylvania, 1961.

Diehl, E. K., "Gas Generation Update", Paper delivered at the Coal Utilization Symposium - Focus on SO_2 Emission Control, Coal and the Environment Technical Conference, Louisville, Kentucky, October 22-24, 1974.

Eckerd, J. W., et al, "Anthracite Metallurgical Briquets as Blast Furnace Fuel", U. S. Bureau of Mines, RI 6383, 1964.

Energy Users Report Reference File, Bureau of National Affairs, Inc., Washington, D. C., 1974.

Feldmann, H. F., et al, "Thermodynamic, Electrical, Physical and Combustion Properties of Seeded Coal Combustion Product", U. S. Bureau of Mines, Bulletin 655, 1970.

Forney, A. J., et al, "Clean Fluid Fuels from Coal and Wastes", Journal of Engineering for Power, Transactions of the American Society of Mechanical Engineers, July, 1973.

Gallo, P. A., "Synthane- A Candidate for Success", Gas World, April 22, 1972, p.334-335.

Gerstle, R. W., et al, "Air Pollutant Emissions from Coal-Fired Power Plants, Report No.2", Air Pollution Control Association, Vol.15, No.2, February, 1965, p.59-64.

Goldish, I., et al, "Systems Study of Conventional Combustion Sources in the Iron and Steel Industry", NTIS, PB-226 294, 1973.

Goodridge, E. R., "Duquesne Light Maximizes Coal Recovery at its Warwick Plant", Coal Age, November, 1974, p.69.

History of Federal Energy Organization, Prepared for the Honorable Henry M. Jackson, Chairman, Committee on Interior and Insular Affairs, U. S. Senate, Serial No.93-19(92-54), U. S. Government Printing Office, 1973.

"Removal of Sulfur from Coal by Treatment with Hydrogen, Phase 1: The Effect of Operating Variables and Raw Material Properties", Research and Development Report No.77, Interim Report No.1, U. S. Department of Interior, Office of Coal Research, May 30, 1973.

Slack, A. V., Sulfur Dioxide Removal from Waste Gases, Noyes Data Corporation, 1971.

Weekly Energy Report, Special Issue, February 4, 1975.

7. GASIFICATION/CONVERSION

"Advanced Coal Gasification System for Electric Power Generation", Research and Development Report No.81, Interim Report No.1, U. S. Department of Interior, Office of Coal Research, June 30, 1973.

"AGA/OCR Symposium Casts More Light on Status of Three Gasification Pilot Plants", Coal Age, January, 1974, p.69.

Aleta, C. R., Coal Gasification: A Review, Cornell University, November, 1971.

Bakulev, G. D., "An Economic Analysis of Underground Gasification of Coal (USSR; translated by Kahone)", U. S. Bureau of Mines, IC 8069, 1962.

Chironis, N. P., "Another Hat in the Energy Ring . . . FMC's Coal to Gas/Oil Process", Coal Age, December, 1971, p.80.

________. "Coal-to-Gas Conversion . . . Search for New Ideas Intensifies", Coal Age, February, 1973, p.106.

"Coal Gasification: State of the Art", Coal Age, January, 1971, p.70.

Eckerd, J. W., et al, "Gasification of Bone Anthracite", U. S. Bureau of Mines, RI 5594, 1960.

"Economical New Coal-to-Gas Process Claimed by Garret Co.", Coal Age, March, 1974, p.86.

Elder, J. L., "The Underground Gasification of Coal", Coal Utilization: Supplementary Volume, John Wiley & Sons, Inc., Chapter 21.

Forney, A. J., et al, "Steam Oxygen Gasification of Various U. S. Coals", Proceedings 2nd International Conference on Fluidized-Bed Combustion, October 4-7, 1970.

"Gas From Coal Moves Step Closer", Coal Age, December, 1970, p.68.

Gilmore, D. W., "Process for Converting Coal into Gaseous and Liquid Fuels", American Institute for Mining Engineers, Preprint SPE 4158, 1972.

Goodridge, Edward R., "American Gasification Processes Inch Closer to Success", Coal Age, December, 1974, p.60.

________. "Status Report: The AGA/OCR Coal Gasification Program", Coal Age, January, 1973, p.54.

Hill, George, "Coal Gasification Program Shifts into High Gear", Coal Age, August, 1972, p.78.

Hiteshue, R. W., et al, "Hydrogasification of Bituminous Coals, Anthracite and Char", U. S. Bureau of Mines, RI 6125, 1962.

Hoke, R. C., et al, A Regenerative Limestone Process for Fluidized-Bed Coal Combustion and Desulfurization, Esso Research and Engineering Co., January, 1974.

Konchesky, J. L., et al, "Influence of Residence Time, Temperature, and Steam Concentration on Coal-Steam Gasification Reactions", U. S. Bureau of Mines, RI 7284, August, 1969.

Lehmann, E. J., et al, Coal Gasification, A Bibliography with Abstracts, COM-74-10967, National Technical Information Service, May, 1974.

Lewis, P. S., "New Technologies in the Offing", Paper delivered at Workshop B: Utilization and Conversion Technology, Anthracite Research Conference, University of Scranton, Scranton, Pa., January 6-7, 1975.

Linden, Henry, "A Reassessment of the Prospects for Coal Gasification", Coal Age, May, 1971, p.73.

Liquefaction and Chemical Refining of Coal, A Battelle Energy Program Report, Battelle Columbus Laboratories, July, 1974.

"Low-BTU Gasification Process will use Coal to Run Teams of Turbines", Coal Age, May, 1972, p.98.

"Lower-Cost Gas from Coal Forecast at A.G.A. Symposium", Coal Age, January, 1969, p.108.

Mills, G. A., "Progress in Coal Gasification", Proceedings 3rd Synthetic Pipeline Gas Symposium, November 17-18, 1970, p.59-78.

Morgan, R. E., "Lurgi-Gasifier Tests of Anthracite", U. S. Bureau of Mines, RI 5420, 1958.

Mudge, L. K., et al, The Gasification of Coal, A Battelle Energy Program Report, Battelle Pacific Northwest Laboratories, July, 1974.

"New Processes Brighten Prospects of Synthetic Fuels from Coals", Coal Age, April, 1974, p.91.

Osborn, Elburt, F., "Clean Synthetic Fluid Fuels from Coal: Some Prospects and Projections", Coal Age, September, 1974, p.31.

Perry, Harry, et al, "Current Developments in the Conversion of Coal to Fluid Fuels in the United States", Trans. 6th World Power Conference, Melbourne, Australia, October 20-27, 1962, vol.7, p.2497-2514.

"Pressurized-Bed Combustion Process Development and Evaluation", Evaluation of the Fluidized-Bed Combustion Process, Vol.1, Westinghouse Research Laboratories, Prepared for the U. S. Environmental Protection Agency, December, 1973.

"Production of Electricity Via Coal and Coal-Char Gasification", R & D Report No.66, Interim Report No.3, West Virginia University Prepared for U. S. Department of Interior, Office of Coal Research, June 15, 1973.

8. GENERAL MINING TECHNOLOGY

Allen, A., et al, "Recovery of Anthracite in a Steeply Pitching Bed by Induced Caving", U. S. Bureau of Mines, RI 5013, 1953.

________, et al, "Longhole Retreat Mining of a Steeply Pitching Anthracite Bed", U. S. Bureau of Mines, RI 4925, 1952.

"Blasting Stumps in Coal Mines", Proceedings 52nd Convention, Coal Mining Institute of America, 1962, p.75-78.

"Anthracite Program of the Bureau of Mines", Coal Age, June, 1963, p.82-84.

Chironis, Nicholas P., "Diesels . . . A Giant Step Underground", Coal Age, March, 1973, p.60.

"COED Pilot Plant Dedicated", Coal Age, November, 1970, p.120.

"Conventional Mining", Coal Age, July, 1969, p.162.

De La Mare, G. W., "Longhole Drilling as an Aid to Mining and Development Work at United Park City Mines Company", Paper presented at the AIME, Annual Meeting, San Francisco, February 15-19, 1959.

Greuer, Rudolf E., "How Overseas Mines Monitor Ventilation", Coal Age, January, 1974, p.71.

Landsidle, C. A., et al, "Preliminary Testing of Brieden Pneumatic Packing Machine", U. S. Bureau of Mines, RI 4978, 1953.

Marovelli, R. L., "Research and Development for Deep Anthracite Mining", Paper presented to the Conference on Advanced Anthracite Technology, Scranton, Pa., January 6-7, 1975.

"Mine Development", Coal Age, July, 1969, p.146.

"Symposium Examines Mine Drainage Research", Coal Age, August, 1970, p.94.

"Mining Guidebook", Coal Age, July, 1969.

"Mining Guidebook", Coal Age, July, 1970.

"Mining Methods and Equipment", Coal Age, October, 1970, p.100.

"Mining Methods: Continuous, Conventional, Longwall", Coal Age, October, 1969, p.116.

"Mixers Agitate Powdered Lime to Neutralize Acid Water Drainage", Coal Age, December, 1974, p.80.

Moebs, Noel N., "Air Sealing as a Means of Abating Acid Mine Drainage Pollution", 151st National Meeting, American Chemical Society, Pittsburgh, Penna., March 22-31, 1966, Preprints, Vol.10, No.1, March 1966, p.93-100.

Morris, A. H., et al, "Impact Ripping - A Survey of Experience to Date", The Mining Engineer, No.157, November, 1973.

Petal, Marvin, "National Coal Board's Research Arm is Coming Up with Major Innovations", Coal Age, January, 1973, p.63.

Peirce Management Corporation, Anthracite Industry Survey Mining Methods - Research - Preparation, Coal Research Board, Project CR-68, Pennsylvania Department of Mines and Mineral Industries, 1967.

"Pre-Assembled Units Speed Hecla Track-Laying Job", Mining Engineering, June, 1974, p.50.

Price, W. S., "Mechanized Longhole Drilling", Compressed Air Magazine, April, 1972, p.10.

Singhal, R. K., "Is the Shearer Loader the Next Big Coal Producer?", Coal Mining and Processing, March, 1970, p.35.

Spencer, John D., "Review of Bureau of Mines' Coal Program, 1965", U. S. Bureau of Mines, IC 8309, 1966.

________. "Review of Bureau of Mines' Coal Program, 1967", U. S. Bureau of Mines, IC 8385, June, 1968.

________. "Review of Bureau of Mines' Coal Program, 1968", U. S. Bureau of Mines, IC 8416, June, 1969.

Stefanko, R., et al, "Fourth Report on Conference on Research and Development Needs for Anthracite Coal Mining", Hazleton, Pa., October 4, 1974.

Stration, John W., "Underground Mining", Coal Age, February, 1974, p.90.

"USBM Calls for Better Equipment", Coal Age, November, 1969, p.100.

Whaite, R. H., "Second Testing of Brieden Pneumatic Packing Machine", U. S. Bureau of Mines, RI 5273, 1956.

Woodruff, S. D., Methods of Working Coal and Metal Mines, Vol.I, II, III, Pergamon Press, 1966.

Yancik, Joseph J., "Coal Research and Development", Coal Age, February, 1974, p.96.

9. CONTINUOUS MINING SYSTEMS

Anderson, F. G., et al, "A Study of Dust-Control Methods for Continuous Mining of Coal", U. S. Bureau of Mines, IC 8205, 1963.

Anderson, R. L., "A Statistical Study of Continuous and Conventional Mining Machine Productivity", Mining Congress Journal, Vol.48, No.5, May, 1962, p.56-62.

Blakely, J. Wes, "The Underground Scene: Continuous Mine Haulage", Coal Mining and Processing, December, 1974, p.42.

Buch, J. W., et al, "Design and Testing of Bureau of Mines Pneumatic Coal Planer", U. S. Bureau of Mines, RI 5380, 1957.

________, et al, "Preliminary Testing of Eickhoff Shearing Machine, Model DEK", U. S. Bureau of Mines, RI 4501, 1949.

________, et al, "Preliminary Testing of Korfmann Universal Shearing Machine, Model SK 20", U. S. Bureau of Mines, RI 4794, 1951.

________, et al, "Preliminary Underground Tests of the Bureau of Mines Scraper-Shaker Loading Machine for Driving Gangways", U. S. Bureau of Mines, RI 4500, 1949.

________, et al, "Status of Bureau of Mines Underground Experimental Work in Light-weight Shearing Machines in Pitching Anthracite Beds", U. S. Bureau of Mines, RI 4798, 1951.

Buntain, D., "British Experiment with Prototype Impact Ripping Machines", Coal Age, March, 1974, p.93-97.

"Continuous Mining", Coal Age, July, 1969, p.150.

Davis, Harold, "Continuous Mining/Continuous Haulage Improves Low-Seam Safety/ Productivity", Coal Age, April, 1973, p.70.

"A Study of Dust-Control Methods for Continuous Mining of Coal", U. S. Bureau of Mines, IC 8205, 1963.

Hunter, D. W., "Bridgewall Mining: A New Concept", Coal Age, September, 1972, p.84.

Mishra, G., et al, Application of a Continuous Mining System in a Medium Pitching Anthracite Bed of Northeastern Pennsylvania, Pennsylvania Coal Research Board, SR-77, 1970.

Schlick, Donald P., "Ventilation of Continuous-Miner Places in Coal Mines", U. S. Bureau of Mines, IC 8161, 1963.

Singh, Madan M., "What to Consider in Selecting Rock Bits", Engineering Mining Journal, June, 1967, p.165.

Singhal, R. K., "More on European Roadheaders", Coal Mining and Processing, July, 1971, p.50.

________. "Roadheaders Preferred in European Mines", Coal Mining and Processing, March, 1971, p.49.

Stahl, R. W., "Extracting Final Stump in Pillars and Pillar Lifts with Continuous Miners", U. S. Bureau of Mines, RI 5631, 1960.

Travenner, W. H., et al, "Use of a Continuous Borer in Mining Pitching Anthracite Beds", U. S. Bureau of Mines, RI 6759, 1966.

10. HYDRAULIC MINING SYSTEMS

Boyd, W. T., "Hydraulic Mining of Coal in the USSR", Proceedings, 8th Conference Coal Research, 1959, p.11-22.

Buch, J. W., et al, "Hydraulic Mining of Anthracite --- Experiments at the Sugar Notch Mine, Wilkes-Barre, Pa.", Mining Congress Journal, Vol.48, No.7, July, 1962, p.22-28.

________. "Hydraulic Mining of Anthracite: Engineering Development Studies", U. S. Bureau of Mines, RI 6610, 1965.

Chironis, N. P., "Water-jet Mining of Coal -- A Promising Technique on the Way", Coal Age, March, 1972, p.67.

Feenstra, R., et al, "Rock Cutting by Jets", Coal Age, June, 1974, p.41.

Fowkes, R. S., et al, "Hydraulic Coal Mining Research. Assessment of Parameters Affecting the Cutting Rate of Bituminous Coal", U. S. Bureau of Mines, RI 7090, 1968.

Malenka, Wilbert T., "Hydraulic Mining of Anthracite Analysis of Operating Variables", U. S. Bureau of Mines, RI 7120, April, 1968.

Nasiatka, T. M., "Hydraulic Coal Mining Research, Tests in a Steeply Pitching Coalbed, Roslyn, Washington", U. S. Bureau of Mines, RI 6276, 1963.

________. "Hydraulic Mining -- The Roslyn Project", Coal Age, June, 1962, p.74-76.

Palowitch, E. R., et al, "Hydraulic Mining Research - A Progress Report", Mining Congress Journal, Vol.50, No.9, September, 1964, p.66-73.

Price, George C., et al, "Hydraulic Coal Mining Research, Development Mining in a Steeply Pitching Coalbed, Roslyn, Washington", U. S. Bureau of Mines, RI 6685, 1965.

Singh, M. M., et al, Coal Mining Using High Pressure Water Jets, National Technical Information Service, PB-235-616, 1973.

Wallace, J. J., et al, "Hydraulic Coal Mining Research Equipment and Preliminary Tests", U. S. Bureau of Mines, RI 5915, 1961.

11. LONGWALL/SHORTWALL MINING SYSTEMS

Barry, A. J., "Roof-Movement Study of Mechanized Retreating Longwall Operation (Cambria County, Pa.)", U. S. Bureau of Mines, RI 5028, 1954.

Brennan, Robert J. et al, "Experimental Longwall Mining in a Pennsylvania Anthracite Mine -- Use of Yielding Steel Props", U.S. Bureau of Mines, RI 6378, 1964.

Davis, Harold, "Barnes and Tucker Concentrates on Longwall", Coal Mining and Processing , July, 1968, p.40.

Jackson, Daniel, "Longwall Mining: Western Style", Coal Age, April, 1971, p.72.

Jones, Donald C., "Five Years of Longwalling Experience Pays Off", Coal Mining and Processing, March, 1971, p.56.

________. "Longwall Mining, 1970", Coal Mining and Processing, December, 1970, p.38.

Keenan, A. M., "Longwall Mining of Coal Seams Pitching 30 Degrees", Paper presented to the Society of Mining Engineers of AIME, Paper No.71-F-336, September, 1971.

Kuti, J., "Engineering Approaches to Rock Mechanics in Longwall Mining", Paper presented to the AIME Annual Meeting, Seattle, Washington, September 22-24, 1971.

________. "Outlook of Longwall Mining Systems in the United States", Coal Age, August, 1972, p.64.

Laird, William, "Thick-Seam Longwalling at Eastern", Coal Age, May, 1971, p.84.

"Longwall Mining", Coal Age, February, 1965, p.90.

"Longwall Mining Today", Coal Age, July, 1969, p.157.

"Longwall Produces Record Tonnage", Coal Age, March, 1971, p.64.

Malenka, Wilbert T., et al, "Experimental Longwall Mining in a Pennsylvania Anthracite Mine -- Use of a Shearer Loader", U. S. Bureau of Mines, RI 6745, 1966.

Martin, C. H., et al, "Shortwall Mining with Power Supports, Part 1", Coal Mining and Processing, December, 1972, p.41.

________. "Shortwall Mining with Power Supports, Part 2", Coal Mining and Processing, March, 1973, p.46.

Nickeson, Floyd H., "New Shortwall Concept Promises Great Productivity Increase", Coal Mining and Processing, July, 1974, p.35.

Roman, George H., "Barnes and Tucker Set a New Longwall", Coal Age, May, 1968, p.84.

Round, C., "Chart Speeds Finding Longwall Support Costs", Coal Age, October, 1973, p.154.

Savidge, Ken, "Sunnyside Goes to Higher Production Longwall Experiment", Coal Mining and Processing, August, 1969, p.34.

Shields, J. J., "Longwall Mining in Bituminous Coal Mines with Planers, Shearer-Loaders, and Self-Advancing Hydraulic Roof Supports", U. S. Bureau of Mines, IC 8321, 1967.

"Shortwall System Combines Miner with Self-Advancing Roof Supports", Coal Age, December, 1973, p.54.

"Singhal, R. K., "Polish Mining Employs Advanced Technology", Coal Mining and Processing, August, 1969, p.38-41.

________. "Which Shearer Loader should you Buy??", Coal Mining and Processing, February, 1970, p.30.

Watson, Brian, "Longwall Produces Record Tonnage", Coal Age, March 1971, p.64.

Zachar, F. R., "Shortwall: A Way to Boost Production", Coal Mining and Processing, December, 1972, p.34.

12. TUNNELS AND DRILLING SYSTEMS

Beall, John V., "Tunnel and Shaft Conference Spotlights Wider Acceptance of Boring Methods", Mining Engineering, July, 1968, p.139.

Bellport, B. P., "Five Case Histories of Tunnel Boring", Mining Engineering, June, 1971, p.49.

"Boring Machines Will Drive the World's Runnels", Engineering News Record, July 22, 1971, p.22.

Dellinger, Thomas B., "Big Hole Drilling, A Study in Depth", Mining Engineering, December, 1965, p.71.

Djatschenko, S. A., "How Efficient is a Rock Drill? New Theory Analyses Performance", Engineering Mining Journal, March, 1967, p.87.

Eadie, George R., "Olga Get 12-Ft. Diameter Air Shaft", Coal Mining and Processing, March, 1967, p.44.

Hewes, R. B., "Raise Boring Cuts Shaft Cost", Coal Age, July, 1970, p.62.

"Holes Through Four Months Early", Engineering News Record, March 6, 1969, p.27.

Howard, Thomas E., "Mine Systems Design: The Next Effort Will Focus on Tunneling", Engineering Mining Journal, June, 1967, p.158.

"In-Strata Drill Features Novel Drill", Coal Mining and Processing, February, 1971, p.46.

McCarthy, D. F., "Raise Boring Techniques", Coal Mining and Processing, March, 1972, p.46.

"Minimole Drives Tiny Tunnels in Hard Rock", Engineering News Record, August 17, 1972, p.31.

"Modern Augering: Big Tonnage From Thin Seams", Coal Age, January, 1971, p.66.

Mullins, William H., "Freeman Coal 'raises drills' Large-Diameter Shafts at Orient No.3", Coal Age, June, 1973, p.66.

"Multiple-Head Auger Recovers Thin Seam in Rugged Terrain", Coal Age, August, 1974, p.78.

Norman, N. E., "Big-Hole Drilling is Coming of Age Underground", Mining Engineering, June, 1968, p.41.

"Preview: Rapid Excavation and Tunneling Conference", Civil Engineering, ASCE, Vol.44, No.4, April, 1974, p.72.

"Rapid-Excavation Concepts Now in Focus as Parameters and Dimensions Emerge", Engineering Mining Journal, January, 1970, p.77.

"Record Vertical Raise Opened at Denison's Elliot Lake Mine", Engineering Mining Journal, July, 1974, p.76.

Robbins, R. J., et al, "Machine-Bored Tunnel and Raises: Their Application to Underground Mining", Mining Engineering, July, 1967, p.156.

Schimmel, J. T., et al, "Use of a Large-Diameter Auger in Mining Pitching Anthracite Beds", U. S. Bureau of Mines, RI 6135, 1962.

Schilling, K. J., "Straight Creek Tunnel", Compressed Air Magazine, February, 1969, p.12.

"Slope driving with a Mechanical Mole", Coal Mining and Processing, March, 1973, p.40.

"3.8 Miles of Tunnel Boring in 190 Days", Engineering Mining Journal, August, 1969, p.98.

"Thin-Seam Auger Boosts Recovery", Coal Age, December, 1970, p.66.

"Tunnel Machine Bores Final Link of Paris Subway Express Line", Engineering News Record, May 30, 1974, p.18.

Wright, W. L., "Kaiser's Sunnyside Mines Go All Out for Raise Boring", Coal Age, January, 1971, p.61.

13. ROOF SUPPORT SYSTEMS

Adler, L., et al, Ground Control in Bedded Formations, Virginia Polytechnic Institute and State University, Research Division Bulletin 28, 1968.

Bower, A. B., et al, "Roof Bits: How to Use Them", Coal Age, April, 1970, p.106.

Barry, A. J., "Resume of Roof Support Methods Used in Coal Mines", Mechanization, Vol.27, No.1, January, 1963, p.37-40.

________, et al, "Spotlight on Roof Control", Coal Mining and Processing, February, 1966, p.18.

Corp, E. L., et al, "Flexible Liners for Underground Support", U.S. Bureau of Mines, RI 6893, 1967.

Curie, R. D., "Mining Anthracite Without Roof Fall Accidents at Colonial Colliery", U. S. Bureau of Mines, IC 6783, 1934.

Calverson, Bert, et al, "Roof Bolts Hold Best with Resin", Mining Engineering, May, 1971, p.54.

Choi, D. S., et al, Designing a Rock Bolting System, Pennsylvania Coal Research Board, SR-73, 1969.

"Controlling Mine Roof", Coal Age, October, 1969, p.132.

de la Cruz, R., et al, Roof Bolt Load and Differential Sag Measurements, Pennsylvania Coal Research Board, SR-53, 1965.

Fairhurst, C., "Roofbolting in Horizontally Laminated Rock", Mining Engineering Journal, February, 1974, p.80.

Fish, Edward, "A Study of Summer Air Conditioning with Water Sprays to Prevent Roof Falls at the Beech Bottom Coal Mine", U. S. Bureau of Mines, RI 3775, 1944.

Forbes, J. J., et al, "Control of Roof and Prevention of Accidents from Falls of Rock and Coal", U. S. Bureau of Mines, IC 7461, 1948.

Herbert, C. A., "Cooling Mine Air During Summer Months to Prevent Roof Falls", U. S. Bureau of Mines, IC 7098, 1940.

"Here's the Metcalfe Roof Bolt", Coal Mining and Processing, November, 1968, p.37.

Horino, F. G., et al, "The Use of Rock Bolts on Wire Rope to Increase the Strength of Fractured Model Pillars", U. S. Bureau of Mines, RI 7568, 1971.

Jones, Donald C., "How Good is Your Bolting Program", Coal Mining and Processing, February, 1966, p.27.

Kelly, L. W., "Economic Benefits of Systematic Roof Bolting in Zeigler No.3 Mine", U. S. Bureau of Mines, IC 7633, 1952.

Kmetz, Warren, J., "Roof Trusses Support Problem Strata", Coal Age, January, 1970, p.64.

Krempasky, G. T., et al, "Design and Development of Precast Concrete Mine Supports: A Progress Report", U.S. Bureau of Mines, RI 6164, 1963.

________. "Installation and Evaluation of Precast Mine Supports", U. S. Bureau of Mines, RI 6253, 1963.

Lewis, W. E., et al, "Ground Support Builds on Firm Foundation", Mining Engineer, Vol.23, No.1, January, 1971, p.73-77.

Mitchell, D. W., et al, "A New Look at Roof Bolts", Coal Mining and Processing, February, 1970, p.34.

"Mini-miner Provides Its Own Positive Roof Support", Coal Age, July, 1968, p.132.

Panek, Louis A., "Design of Bolting Systems to Reinforce Bedded Mine Roof", U. S. Bureau of Mines, RI 5155, 1956.

Parker, Jack, "How to Improve Roof Support", Engineering Mining Journal, January, 1974, p.90.

Pizoli, George L., "Robena Mine Researches Roof Bolting Methods", Coal Mining and Processing, February, 1966, p.23.

"Roof Control", Coal Age, July, 1969, p.167.

"Roof Control: Major Safety Problem", Coal Age, March, 1970, p.78.

"Roof Control Methods", Coal Age, October, 1970, p.114.

Stahl, R. Ward, "Survey of Practices in Controlling Roof at Intersections and Junctions in Underground Coal Mines", U. S. Bureau of Mines, IC 8113, 1962.

Thomas, Edward, "Control of Roof and Prevention of Accidents from Falls of Rock and Coal. Suggested Roof Supports for Use at Faces in Conjunction with Mechanized Loading", U. S. Bureau of Mines, IC 7471, 1948.

________. "Roof Bolting in the United States", U. S. Bureau of Mines, IC 7583, 1950.

________, et al, "Suspension Roof Support. Progress Report 1", U. S. Bureau of Mines, IC 7533, 1949.

"Yielding Hydraulic Supports Provide Maximum Safety", Coal Age, June, 1970, p.66.

"You Can Drill Small Diameter Roof Bolt Holes", Coal Age, September, 1971, p.80.

Young, H. C., "Roof Bolting in Alabama Coal Mines and Iron Ore Mines", U. S. Bureau of Mines, IC 7678, 1954.

14. MATERIAL TRANSPORTATION

"Add Diesel to Hydraulic . . . Get Dynamic Breaking for Safe Hauling", Engineering Mining Journal, October, 1969, p.83.

Burns, James A., "New Concepts in Mineral Transportation", Mining Engineering, November, 1973, p.49.

Courtney, William J., et al, "Pneumatic Stowing: It Must be Looked at Now", Coal Mining and Processing, February, 1974, p.27.

Dierks, H. A., et al, "Developing a Lock-Hopper Feeder for Hydraulic Hoisting of Coal", U. S. Bureau of Mines, RI 6347, 1964.

Fijalkowski, B. T., et al, "High-Duty Belt Conveying Modern Drives and Automation", Colliery Guardian, November, 1970, p.558.

Gronseth, James R., et al, "How Modern Mine Hoists are Selected", Engineering Mining Journal, June, 1965, p.183.

Gurney, Mehmet, "Hydraulic Stowing Improves Coal Mine Safety and Output", Mining Engineering, July, 1969, p.113.

Hardie, Robert C., et al, "How Automatic AC Hoisting was Tailored from Manual Double Drum Unit", Engineering Mining Journal, October, 1967, p.81.

"Haulage and Hoisting", Coal Age, July, 1969, p.172.

"Hydraulic Coal Hoisting . . . In Principle and Practice", Coal Age, November, 1973, p.60.

Kane, L. J., et al, "Pneumatic Coal Transport: Difficult But Promising", Power Engineering, Vol.70, No.8, August, 1966, p.58-59.

Konchesky, J. L., et al, "Pneumatic Transportation of Mine Run Coal Underground", Mining Congress Journal, December, 1971, p.42-46.

"Low-Pressure Jet Stower", Colliery Guardian, November, 1970, p.566.

Manula, C. B., et al, Planning Belt Conveyor on Networks Using Computer Simulation, Pennsylvania Coal Research Board, SR-63, 1967.

McDermott, W. F., et al, "The World's First Long Distance Iron Ore Slurry Pipeline", Mining Engineering, January, 1969, p.86.

"Mechanical, Hydraulic, Pneumatic Options in Deep Mine Transport", Coal Age, July, 1974, p.61.

"Mining Guidebook - Transportation Special", Coal Age, July, 1974.

Nickeson, Floyd H., "Hydraulic Pipeline Makes Continuous Haulage Possible", Coal Mining and Processing, July, 1974, p.43.

"The Fight Over Moving Coal by Pipeline", Business Week, July 27, 1974, p.36.

"The Longest, Largest Coal Slurry Pipeline Ever Built", Coal Mining and Processing, February, 1971, p.37.

Oguz, S., et al, Evaluation of a Monorail Mine Haulage System, Pennsylvania Coal Research Board, SR-78, 1971.

"Pipeline Transport Wins Out Over Rail", Coal Age, March, 1969, p.105.

Pipilen, A. P., et al, "Hydraulic Transport of Broken Coal", Transactions American Institute of Mining Engineers, Vol.229, p.427-435.

________, et al, "Hydraulic Transport of Coal", U.S. Bureau of Mines, RI 6743, 1966.

"'Revolutionary' Underground-to-Surface Slurry Pipeline Passes First True Test", Engineering Mining Journal, July, 1974, p.75.

Sanford, R. L., et al, A Simulation Model on the Optimal Design of Belt Conveyor Systems, Pennsylvania Coal Research Board, SR-47, 1965.

"Self-Loading Scraper Moves Refuse Efficiently and Inexpensively", Coal Age, June, 1974, p.78.

Singhal, R. K., "Hydraulic Hoisting of Coal", Coal Mining and Processing, June, 1970, p.44.

Spencer, J. D., et al, "Pneumatic Transport of Solids", U. S. Bureau of Mines, IC 8314, 1966.

"Suspended Monorail System Provides Effective Haulage", Coal Mining and Processing, July, 1969, p.38.

Tears, Kenneth, "Modern Skip Winding", Colliery Guardian, November, 1970, p.547.

Tiley, G. L., "The Case for Tower-Mounted Friction Hoists", Engineering Mining Journal, June, 1967, p.177.

"White Pine Preparing to Use New Transport Concept", Mining Engineering, July, 1968, p.154.

Willmott, L. F., et al, "Aqueous Slurries of Coal and Granular Materials; A Bibliography", U. S. Bureau of Mines, IC 8165, 1963.

15. STRIP MINING

Alder, L., et al, Analyzing Excavation and Materials Handling Equipment, Virginia Polytechnic Institute and State University, Research Division Bulletin 53, 1970.

Allen, James H., "The Big Hole Gets Bigger", Mining Engineering, November, 1968, p.58.

Day, D. A., Construction Equipment Guide, John Wiley & Sons, 1973.

Garfield, Lawrence A., "Rapid Excavation -- A Perpetual Goal", Mining Engineering, June, 1971, p.45.

Howard, Thomas E., "Rapid Excavation", Scientific American, November, 1967.

"The Surface Mining of Coal", Energy Perspectives, Battelle Memorial Institute, March, 1974.

16. MISCELLANEOUS REFERENCES

A Dictionary of Mining, Mineral and Related Terms, U. S. Bureau of Mines, Government Printing Office, 1968.

"Acid Mine Water and Limestone = Clean Stream", Coal Age, February, 1969, p.112.

"AIME Meets in Washington", Coal Age, April, 1969, p.129.

"AMC Reviews Progress, Problems", Coal Age, June, 1969, p.92.

Annual Report of the Office of Mines and Land Development, Commonwealth of Pennsylvania, Department of Environmental Resources, Selected dates.

"Anthracite Program of the Bureau of Mines", Coal Age, June, 1963, p.82-84.

"At U. S. Steel's Coal Mines, Safety is an On-Line Concept", Coal Age, October, 1973, p.97.

Aurand, H., From the Molly Maguires to UMW, Temple University Press, 1971.

"Australian Coal --- A Factor in World's Steel Equation", Engineering Mining Journal, November, 1970, p.244.

Berger Associates, Inc., Swatara Creek Mine Drainage Pollution Abatement Project Part Two, SL 126-2, 1972.

"Blue Coal's Wanamie No.19 Water Treatment Plant", Coal Mining and Processing, October, 1969, p.56.

"Bureau of Mines Research and Technologic Work on Coal", U. S. Bureau of Mines, IC 8189, 1962.

"Bureau of Mines Research and Technological Work on Coal, 1964", U. S. Bureau of Mines, IC 8277, 1965.

Mineral Facts and Problems, 1965, U. S. Bureau of Mines, 1965.

"Research and Technological Work on Coal and Related Investigations", U. S. Bureau of Mines, IC 7904, 1959.

"Research and Technological Work on Coal and Related Investigations", U. S. Bureau of Mines, IC 7905, 1959.

"Review of Bureau of Mines Coal Program 1966", U. S. Bureau of Mines, IC 8357, 1967.

"Trends in the Minerals Industry", U. S. Bureau of Mines, IC 8547, 1972.

The Coal and Metal Miners Pocket Book, 9th Edition, International Textbook Company, Scranton, Pa., 1904.

"Christopher Attacks Mine Drainage Problem", Coal Age, September, 1969, p.80.

"Coal Mine Refuse and Fly Ash Team Up as Base Material for Highway Construction", Coal Age, December, 1973, p.84.

"Coal Industry Meetings ... Summer of 1972", Coal Age, August, 1972, p.81.

"Coal Mining Company Builds . . . New Land from Refuse Piles", Coal Age, April, 1972, p.118.

"The Constancy of Change . . . What Coal Mining is Today", Coal Age, July, 1971, p.153.

Fultz, Charles, E., "Efficient Mining, Effective Delivery, Ultimate in Storage", Coal Age, January, 1969, p.54.

Grim, E. C., et al, Environmental Protection in Surface Mining of Coal, EPA-670/2/74/093, October, 1974.

Hunter, T. W., "Anthracite, Mineral Facts and Problems", U. S. Bureau of Mines, Bulletin 650, 1970.

Ironman, Ralph, "Bevercotes Colliery Pioneers Automation", Coal Mining and Processing, April, 1974, p.64.

________. "British Colliery Pioneers in Modernization", Coal Mining and Processing, October, 1974, p.42.

Johnson, G. E., et al, "The Use of Coal and Modified Coals as Adsorbents for Removing Organic Contaminants from Waste Waters", U. S. Bureau of Mines, RI 6884, 1966.

Kostenbader, D. D., et al, "High-Density Sludge Treats Acid Mine Drainage", Coal Age, September, 1970, p.90.

Keystone Coal Industry Manual, McGraw-Hill, Inc., 1974.

Krickovic, S., "Acid Mine Drainage Pollution Control -- Approach to Solution", _Mining Congress Journal_, Vol.52, No.12, December, 1966, p.64-68.

________, et al, "Methane Emission Rate Studies in a Central Pennsylvania Mine", U. S. Bureau of Mines, RI 7591, 1971.

Laws of the United States Relating to Water Pollution Control and Environmental Quality, Committee on Public Works, U. S. House of Representatives (93-1) 1973.

Lorenz, Walter C., "Progress in Controlling Acid Mine Water: A Literature Review", U. S. Bureau of Mines, IC 8080, 1962.

"Mine Drainage", _Coal Age_, July, 1969, p.181.

Moore, A. S., et al, "Removing Acid Gas by Agitated Absorption", U. S. Bureau of Mines, RI 5730, 1961.

Moore, T. D., et al, "Effect of a Surface Borehole on Longwall Gob Degasification (Pocahontas No.3 Coal Bed)", U. S. Bureau of Mines, RI 7657, 1972.

Parker, Jack, "How to Design Better Mine Openings", _Engineering Mining Journal_, December, 1973, p.76.

________. "Practical Rock Mechanics for Miners", _Engineering Mining Journal_, June, 1973, p.104.

________. "The Relationship Between Structure, Stress and Moisture", _Engineering Mining Journal_, October, 1973, p.91.

"Reclamation . . . A Peabody Coal Environmental Specialty", _Coal Age_, October, 1971, p.124.

Seet, Maurus, "Coal in China is Bursting at the Seams", _Mining Engineering_, September, 1971, p.68.

"SME Coal Division Holds Spring Meeting", _Coal Age_, June, 1970, p.92.

Stahl, R. W., et al, "Survey of Face Ventilation Practices in Coal Mines", U. S. Bureau of Mines, RI 5560, 1960.

"Symposium Studies Acid Mine Drainage", _Coal Age_, July, 1968, p.93.

"U. S. Steel Solves Acid-Water Problems", _Coal Age_, May, 1969, p.64.

"Ventilation and Drainage", _Coal Age_, July, 1969, p.178.

Vogel, G. J., et al, Reduction of Atmospheric Pollution by the Application of Fluidized-Bed, Combustion and Regeneration of Sulfur Containing Additives, Argonne National Laboratory, Prepared for the U. S. Environmental Protection Agency, June, 1973.

Wall Street Journal, Selected Issues.

"What's New: Theme at Rocky Mountain Institute", Coal Age, August, 1969, p.72.

"Wilmot Preparation Equipment", Bulletin CC-552, Wilmot Engineering, White Haven, Pa.

Wolfson, D. E., "Use of Preheated Coal in Carbonization", U. S. Bureau of Mines, RI 7630, 1972.

Yancik, Joseph J., "Some Impressions and Observations of Soviet Coal Mining", Coal Age, July, 1974, p.63.

Zabban, Walter, et al, "Converting AMD to Potable Water by Ion Exchange Treatment", Coal Age, July, 1972, p.107.

Zaharieu, G. K., "What's Ahead for Russian Mining?", Mining Engineering, December, 1974.

UNITED STATES DEPARTMENT OF THE INTERIOR

ADVISORY COMMITTEE ON SAFETY STANDARDS FOR ANTHRACITE COAL MINES

Recommendations to the Secretary concerning the Federal Coal Mine Health and Safety Act of 1969 as it would apply to Anthracite Coal Mines.

This plea for consideration will point to several instances where change is an urgent need with substantive supporting documentation. It is being made after thorough consultation with labor, management and technical people knowledgeable in Anthracite mining and vitally interested in the Anthracite industry and its ability to survive. Because of unique physical conditions and current economic problems, implementation of the 69 Act creates difficult problems for the Anthracite mining industry. The many problems are indigenous to the Anthracite field and are of such magnitude that the existence of the industry is endangered.

Some of the problems in need of urgent attention follow:

<u>Sec. 303 (a)</u> - This section requires that all coal mines be ventilated by mechanical ventilation equipment. Application of Sec. 303 (a) may directly affect 50% of the underground industry.

The problem in gaining compliance with this provision is largely economic; however, technical difficulties are anticipated. To provide mechanical ventilation, the operator must obtain and install a main fan of adequate capacity and provide a suitable mine ventilation system. On the basis of cost, fan acquisition and installation may represent a small portion of the total expenditure involved. In naturally ventilated shallow mines, airflow is often broadcast through underground openings without control. In such cases, installation of a mechanical ventilation system will require the construction of stoppings, seals, regulators and overcasts to provide adequate control and effective use of intake air. The cost of such construction can be expected to greatly exceed initial fan costs. In addition, time required to gain compliance with Sec. 303 (a) will vary from mine to mine and will be directly related to the amount of underground construction required and natural or manmade conditions existent at construction sites.

The mines affected by this provision are small operations with limited available capital. Many will not have access to necessary experienced technical people to determine required fan capacity or to design a ventilation system acceptable to the District Manager's desire or the federal inspectors' interpretation. Even if this were possible, the financial encumbrance in most cases would mitigate against such an outlay and would result in many more complete closures of operating mines. Thus a modification of this portion of the Act must be given immediate attention.

Sec. 303 (b) - Representatives of operators, labor and technical people contend that specified minimum air quantities required by this section to be present in the last open crosscut (9,000 c.f.m.) and at each working face (3,000 c.f.m.) are excessive and illsuited where development results in which fullbox breast mining is practiced. It is generally conceded that, although the area of the manways is limited and may be as little as 7 to 9 square feet, 3,000 c.f.m. of air can in most cases be delivered to the working face without excessive air velocities in the breast manways. However, the requirement that 9,000 c.f.m. of air reach the last open crosscut in a set of breasts is considered a major operating problem in such mines. Representatives of operators, labor and technical people contend that air quantities of this magnitude will, in instances, when not necessary for methane control, lead to excessive air velocities and airborne dust resulting in a diminution of safety in the affected area. You must be aware that explosive dust is not a problem in Anthracite, methane has never been found in most of these mines and respirable dust levels are at a utopian range 1.0 mg/m^3 or less. This should be evidence enough that ventilation is, and has been, of ample sufficiency without other restrictive impositions.

Sec. 303 (c) - We contend that regulations appended to the statutory provision [303 (c) as published in the Federal Register, Part 75, Sec. 75.302-4 (a)] are inappropriate and unnecessary.

Sec. 75.302-4 (a) deals with auxiliary fans and states, in part, "The fan shall be of a permissible type, maintained in permissible condition." In the past the Anthracite industry has used nonpermissible auxiliary fans installed outby the last open crosscut and operated blowing to the face without any lesser degree of safety.

We strongly suggest this rule continue to apply without exception.

Sec. 303 (k) - This provision requires that air that has passed through an abandoned area or an area which is inaccessible or unsafe for inspection shall not be used to ventilate any working place in any mine.

Because of past mining practices and natural conditions, extensive areas of broken ground and rubble may occur adjacent to existing mine intake aircourses. Underground fan installations are frequently installed in the mine openings inby such areas to prevent the loss of ventilating air through the broken ground and rubble. In such installations intake air enters the mine through the mine entry and through the broken ground or caved area. Such installations may be in violation of Sec. 303 (k) and past history in Anthracite, along with technical advice and assistance on investigating this practice, indicates it is safe and practical.

Field investigation of underground airflow in mechanically ventilated underground mines may show that violations of Sec. 303 (k) are widespread. If this is the case, the economic impact of this provison may prove overwhelming. Although specific information is not currently available, this provision of the Act is anticipated to be a major problem in the underground Anthracite industry.

Sec. 303 (z) (2) - This provision requires that all areas of a coal mine from which the pillars have been wholly or partially extracted and abandoned areas shall be ventilated by bleeder entries, bleeder systems, or equivalent means or be sealed. It further specifies that when sealing is required, such seals shall be in an approved manner so as to isolate with explosion-proof bulkheads such areas from the active workings of the mine.

The Anthracite region has specific problems of major importance directly related to conditions resulting from past practices and natural conditions and the economic and construction problems created by general application of this provision could prove devastating.

Most deep Anthracite mines are operated in areas of prior mining and in many cases active openings have penetrated extensive areas of broken ground communicating with abandoned areas. Ventilation of the connected gob areas under such conditions may often prove technically impractical and construction of extensive tunnel-liner type explosionproof seals may be economically infeasible. This provision is one more example of unnecessary, inequitable, regulations where Anthracite is concerned. Once again absence of the explosive dust and methane combination indicates the need for flexible interpretation and implementation if conditions warrant and should be practiced.

On steep pitches in multiple level operations the developing level is tapped into the abandoned levels above to provide water drainage from the upper levels and reduce the hazard from inundation, should the barrier pillar between levels fall. With this sytem of mining the upper levels do not remain sealed and ventilation may not be adequate to fulfill the intent of Sec. 303 (z) (2) as expressed in the Dec. 16, 1969, Conference Report, H.R. 91.761.

Secs. 303 (a), (d) and (z) (2) are considered critical to continued operation of underground Anthracite mines. In some cases the cost to gain compliance with these provisions may exceed the value of the mine. It is urgently necessary to have this language modified for Anthracite immediately. This is completely alien to safety in Anthracite mining and must be corrected in language and implementation.

Secs. 305 to 310 inclusive - This portion of the Law may be a major problem. We have not been able in the limited time available to do much more than scratch the surface.

Reportedly, all Anthracite underground electrical systems are ungrounded low-voltage alternating currents. The power cables throughout the mine are not in conduit or armor. These two items could have a very heavy financial impact on the industry since they could require extensive changes in the mine power distribution system. Meetings would be required between the Anthracite industry's and the Bureau's electrical personnel to determine the extent of this problem.

While inspections, and conferences, are carried on notices of alleged violations and subsequent civil penalties under these sections should cease, except where proven imminent danger exists.

Sec. 312 - The Anthracite operators believe that requiring the map to be brought up to date at least every 6 months causes a major hardship, especially in many cases where only one or two breasts are mined in a 6-month period. Because the operator must hire a certified engineer to bring the map up to date and because of the scarcity of certified engineering personnel in the Anthracite region, this creates an unnecessary burden and should be modified and adds no safety factor.

Sec. 313 - Due to the method of Anthracite mining which approximates the open slope mining of metal and nonmetallic mines being used as a basic system, the blasting provisions of this Act do provide the industry with considerable problems, especially when shooting off a vertical face. At times they deem it necessary to shoot over 20 holes at one time.

It is hazardous for a man to try to face up each shot separately on a steep pitch. At present there is no permissible blasting device for over 20 holes. In the long-hole method of mining, which is considered to be one of the safest in steeply pitching veins by miners, operators, inspectors and technical people, holes 40 feet long or more are fired, and when using electric detonators it is difficult to assure the full detonation of the powder train; the full detonation can be assured with primacord. The primacord would be totally confined in the hole the same as explosives. We suggest U.S. Secretary of Interior and Director of U.S. Bureau of Mines consider modifications to allow use of primacord in Anthracite mines under U.S. Bureau of Mines supervision.

Sec. 317 (e) - The material published in the Federal Register of Dec. 28, 1970 requires lighting on all mining machines. In some Anthracite mines where air-driven machines are used at the face, there is no electricity in that part of the mine. We do not think they should be required to put the added hazard of electrical power wires in the face area for only lighting. Comments prepared under the supervision of highly qualified people presented to the U. S. Bureau of Mines in Washington, D.C. on August 25, 1971 were apparently overlooked. We suggest the U.S. Secretary of Interior and the Director of the U. S. Bureau of Mines make a careful study of these submissions and modify the regulations accordingly.

Sec. 75.200 - Roof Control - The general information required in roof control plans include many unnecessary and superficial items, causing additional clerical and engineering work. Due to the unique mining methods in Anthracite this poses an undue hardship on the Anthracite industry and should be changed after consultation without undue delay.

Sec. 75.300-2 (g) - We suggest this section be modified to include the following language. In Anthracite mines underground installations of main fans may be accepted and approved as an adequate means of mechanical ventilation so long as a constant and adequate supply of air totally free of methane and meeting quality criteria of the Act is provided.

Sec. 75.300-2 (h) - We suggest this section be modified to include the following language. Booster fans shall be installed in fire resistant surroundings and in such locations as to prevent recirculation of the ventilating current.

Sec. 75.300-2 (i) - We suggest this section be modified to include the following language. If a booster fan stops an alarm device will be attached to booster fans that will be automatically activated if the fan stops.

Sec. 75.300-2 (j) - We suggest this section be modified to include the following language. Following any disruption in the ventilating current, no workmen will be allowed to reenter the active workings of the mine until reestablishment of the ventilating circuit and after examination by a certified person.

Sec. 75.300-3 (a) - In many small mines in the Pennsylvania Anthracite area the mine electrical power is de-energized at the source when no men are in the mine, particularly overnight, weekends and idle periods. A pre-shift examination is made after the fan is in operation, before the mine power is energized or workmen enter the mine. This, we feel, is adequate protection, and continuous operation of the fans causes undue hardship and is unnecessary in the cause of any safety factor.

Sec. 75.3003-3 (a) (4) - We suggest this section be modified to include the following language. Except in the event of de-energization of the mine power supply and all men are withdrawn from the mine. In such case the fan will be operated for a period sufficiently long to change the volumes of air in the mine atmosphere. An examination of the active workings of the mine will be made before the mine power is energized.

OR

Sec. 75.300-3 (a) (4) - All main fans should be kept in continuous operation except during periods of non-working time when all men are withdrawn from the mine and the mine power system is de-energized. To provide for resumption of work restoration of ventilation shall be established after which all working places and other active workings where methane is likely to accumulate are examined by a certified person and before the mine power is energized.

Sec. 75.301 - There is no objection to most of the requirements of the quantity, quality and velocity of air in the statutory provisions of 75.301. However, the requirement of 9,000 cubic feet a minute in the last open crosscut, or 3,000 cubic feet a minute at each working face, without regard for the cross-sectional area of entry, would cause other serious hazards, from the high velocity necessary to produce the quantity of air.

A 3' x 3' manway to full box places in heavy-pitching Anthracite seams, would necessitate 1,000 feet per minute velocity, which is more than 2 times the recommended velocity for the safe use of a safety lamp. It would also cause numerous other hazards which would make unsafe working conditions and this matter should be immediately considered for corrective language without delay.

Sec. 75.301 (a) - We suggest this section be modified to include the following language. In Anthracite mining systems where velocities and quantities cited under 75.301 present hazards to the health and safety of the miner, the volume of air shall be at least 200 c.f.m. for each person in any split. This volume shall be considered a minimum requirement. Additional air shall be provided as may be required to dilute adequately and carry off flammable and harmful gasses and fumes.

Sec. 75.301 (1) (a) - We suggest this section be modified to include the following language. In Anthracite mining practice a minimum quantity of 200 c.f.m. of air per man shall reach each working face from which coal is being cut, mined or loaded and any other working face so designated by the District Manager, in the approved ventilation plan.

Sec. 75.301 (4) (a) - We suggest this section be modified to include the following language. In Anthracite mining practice the flow of air shall have sufficient velocity to keep the working face clear of flammable explosives and noxious gasses, dust and explosive fumes.

Sec. 75.301-4 - The formula to be used to figure mean velocity increases the actual velocity of the air traveling behind the brattice, without considering the quality of the air, or the quantity required to carry off and render harmless all fumes and noxious gasses.

The requirement that auxiliary fans be equipped with permissible type motors is unnecessary, we feel, in non-gassy mines when the fan is located outby the last open cross-cut, in a manner to prevent the recirculation of the air. We also question the necessity of this provision at all where no methane is ever found and contend this should be modified for Anthracite mines now.

Sec. 75.302 (4) (a) - We suggest this section be modified to include the following language. Except when such installation is used on intake air and positioned outby the last open crosscut and provided methane is not present in the intaking air current.

Sec. 75.302-4 - This should be modified so as to provide that in non-gassy mines non-permissible type motors and fans could be used whether inby or outby the last open crosscut. In gassy mines the non-permissible type motors and fans should be allowed outby the last open crosscut.

Sec. 75.302-4 (d) - We suggest this section be modified to include the following language. Except under Sec. 75.300-3 (a) when using auxiliary fans and following periods of idleness, the procedure established under Sec. 75.300-3 (a) shall be followed before starting auxiliary ventilating equipment.

Sec. 75.302-4 (e) - We suggest this section be modified to include the following language. Auxiliary fans in Anthracite mines shall not be used when methane is present in the intaking air current.

Sec. 75.302-4 (f) - We suggest this section be modified to include the following language. Except in Anthracite mining practice where the installation of line brattice or other approved device may become ineffective by reason of falling coal.

Sec. 75.302-4 (g) - We suggest this section be modified to include the following language. Except where measurable amounts of methane are not present in the intaking air current and auxiliary fan operation is conducted under the approved ventilation plan.

Sec. 75.303 - The requirement that the pre-shift examiner use an anemometer on pre-shift examination, we feel, has been, and is, unnecessary. Accurate tests to prove the absence of methane and oxygen deficiency, and visual inspections of the other conditions of the place, have proved satisfactory. Detailed studies of the ventilating currents should be made at times other than the pre-shift examination. Pennsylvania Anthracite Mine Law requires, and certifies, the miner make a thorough inspection of his place immediately prior to starting work, and at periodic intervals during the working shift. We feel this has proven more than adequate in Anthracite and this section should be modified to reflect this position.

Sec. 75.304-3 - We believe this section delegates too much authority to the Coal Mine Safety District Manager and is superfluous because it is covered in other sections of rules and regulations and that it should be completely deleted in so far as Anthracite mining is concerned.

Sec. 75.307 - We recommend that the qualified persons to make methane examinations should include certified miners in those states where the state requirements provide that the miner be qualified to take such tests.

Secs. 75.500 - 75.501 - 75.502 - The Pennsylvania Anthracite Mine Law and the U. S. Bureau of Mines, up until this time, recognized the distinction between gassy and non-gassy mines. Many Anthracite mines, not necessarily above the defined water table, have worked for years, some completely mined out without ever finding gas by any means including chemical analysis. Large areas of the Anthracite coal fields have been completely free of gas and Anthracite dust is not explosive, thus this hazardous condition is non-existent in Anthracite.

Under these conditions, it is an unnecessary hardship to require permissible-type equipment beyond the last open crosscut in those mines. If it is safe to operate non-permissible equipment in those mines until March 1974, why is it not possible to continue under the same regulations? The gassy and non-gassy classifications should be based on whether or not gas has ever been found in quantities of over 0.25% methane and we strongly recommend modification under these sections to allow this in mines so classified.

Sec. 75.503-1 (a) - This section should be amended so that the operator of a non-gassy Anthracite mine shall not be required to complete the electrical survey and electrical face equipment. The reason for this is that in a non-gassy Anthracite mine the requirement is not relevant and the cost to the small operators where it is not relevant does not seem to be valid. This same observation or recommendation applies to Sec. 75.503 (b) and Sec. 75.504. Modifications to correct this matter are urgently requested.

Sec. 75.521 - Should be clarified as to what constitutes exposed power conductors because without such a definition the remaining portions of the sections is not understandable or, at least, is not clear. It is believed that this area so far as it affects Anthracite mines should be modified by definitions and recommendations after thorough consultations with Anthracite people knowledgeable on this matter.

We feel the entire portion of rules and regulations setting forth standards on electrical requirements must be reevaluated in the light that the use of electricity in Anthracite mining is completely on a different plain in other coal mining and applicability of the various rules and regulations set forth in the Federal Register are totally inequitable to Anthracite.

Sec. 75.1100-2 (c)-2 - Should be excluded in the case of Anthracite mines where the main haulageways are driven in rock strata and no combustible materials are found to be present. There is a distinction between the working sections in the Anthracite mines and other coal mines so that to require the same fire fighting equipment in both does not make sense. The failure to differentiate between the two types of mines has throughout the regulations been permitted to cause an undue and unreasonable hardship on the small Anthracite operations. Apparently no attention has been given to the fact that there is no danger of explosive dust at any time in Anthracite mining and reasonable modifications are totally justified for Anthracite mines.

Sec. 75.1200 (d) - We contend that the requirement of spacing of contour lines is impossible to comply with in heavy-pitching seams of Anthracite mines and therefore this subsection should be amended in order to be reasonable and in order for the engineers to give as much detail as is possible under the circumstances without the restriction of 10 foot elevation levels. Engineering people have advised that to comply with this requirement would result in a complete black out in the steep pitch Anthracite areas mapped. It is an urgent need on the part of your office to seek advice on this and make necessary corrections.

Sec. 75.1200-1 (m) - We contend that the requirement to establish contour lines on the mine maps, at the scale and intervals required, would be impossible to plot on the map, or to distinguish on heavy-pitching Anthracite seam maps. Engineering people have advised that to comply with this requirement would result in a complete black out in the steep pitch Anthracite areas mapped. It is an urgent need on the part of your office to seek advice on this and make necessary corrections.

Sec. 75.1400 - No known effective safety catches have been developed for use on mantrip cars on steep-pitching slopes. Until such devices have been developed, this requirement should be eliminated from the Law.

Sec. 75.1403-8 (b)(c) - In thin, steep-pitching seams, in the Anthracite area, it is impossible to maintain continuous clearance along the haulageways, without blasting top or bottom rock of the seam, causing other, more serious hazards.

Consideration should be given to the method of operating the haulage equipment and the speed, the necessity for men to travel the haulageways while the haulage equipment is in motion, the use of shelter holes along the haulageway, man travelway, etc. We suggest your department refrain from imposing the conditions under the above mentioned sections until a thorough conference on the matter is held and correct information is considered.

Secs. 75.1404, 75.1404-1, 75.1405, 75.1405-1 - We contend that reference contained herein is to high-speed locomotives not used in Anthracite mines. Further that the Secretary has the right to modify where safety is not adversely affected under Public Law 91-172-91st Congress. We feel the Secretary without due course of a hearing should make the necessary changes with knowledge that a distinction must be drawn between Anthracite and Bituminous haulage systems.

Sec. 75.1704-1 (a) (b) (c) 1, 2 - The general criteria describing escapeways as to height, width, stairways elevators, etc., does not consider the steep-pitching multi-veins of Anthracite mines, including full box place manways, rock holes, etc.

The fact that the District Manager may consider other escapeways could take care of the situation. However, we feel the U. S. Department of the Interior should immediately confer on this matter, and, after due course of receiving technical advice, make the necessary changes so that there is uniformity in application.